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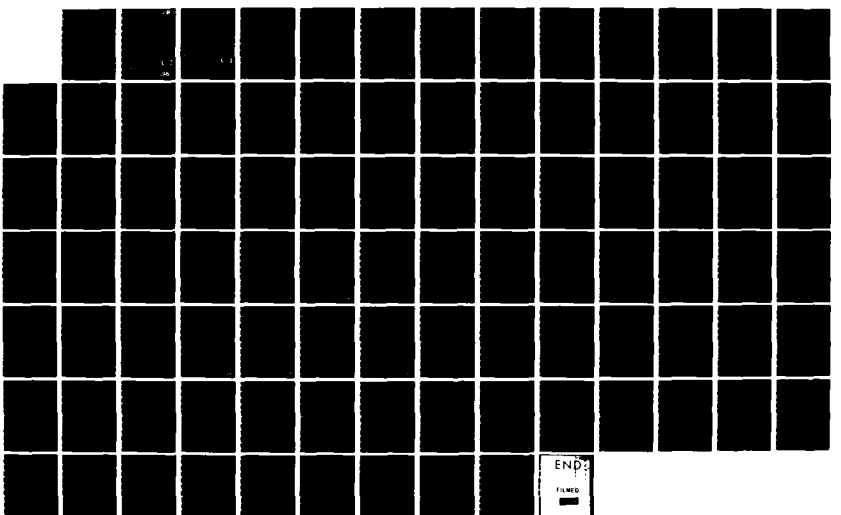

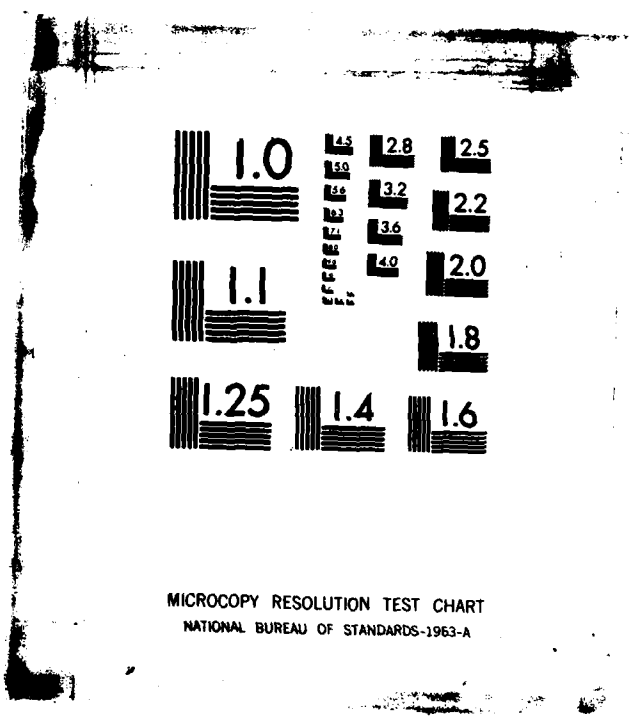

RECONCILIATION OF PRESENT VALUE-UNIT COSTS AND UNIFORM ANNUAL COSTS FOR MUNITIONS MANUFACTURING PINK WASTEWATER TREATMENT ALTERNATIVES

CONTRACT NO. DAAK70-82-M-0308

(TASK NO. 1)

V. J. CICCONE & ASSOCIATES, INC.

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(TASK NO. 1)

BY

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JANUARY, 1983

PREPARED FOR

U.S. ARMY TOXIC AND HAZARDOUS MATERIALS AGENCY
ABERDEEN PROVING GROUND, MD 21010

and

U.S. ARMY MOBILITY EQUIPMENT RESEARCH & DEVELOPMENT COMMAND
FORT BELVOIR, VA 22060

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: DRXTH-TE-CR-83195	2. GOVT ACCESSION NO.: AD-A137 357
3. RECIPIENT'S CATALOG NUMBER:	
4. TITLE (and Subtitle): RECONCILIATION OF PRESENT VALUE-UNITS COSTS AND UNIFORM ANNUAL COSTS FOR MUNITIONS MANUFACTURING PINK WASTEWATER TREATMENT ALTERNATIVES.	5. TYPE OF REPORT & PERIOD COVERED: FINAL REPORT JUL 1982-JAN 1983
	6. PERFORMING ORG. REPORT NUMBER:
7. AUTHOR(s): DR. VINCENT J. CICCONE MR. CHARLES V. CICCONE	8. CONTRACT OR GRANT NUMBER(s): DAAK70-82-M-0308
9. PERFORMING ORGANIZATION NAME AND ADDRESS: V.J. CICCONE & ASSOCIATES, INC. 14045 Jefferson Davis Hwy. Woodbridge, VA 22191	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 62720A, IL162720D048, EW, W-47
11. CONTROLLING OFFICE NAME AND ADDRESS: U.S. ARMY TOXIC & HAZARDOUS MATERIALS AGENCY, ABERDEEN PROVING GROUND, MD 21010	12. REPORT DATE: JANUARY 1983 13. NUMBER OF PAGES:
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office): U.S. ARMY MOBILITY EQUIPMENT RESEARCH & DEVELOPMENT COMMAND FT. BELVOIR, VA 22060	15. SECURITY CLASS. (of this report): UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release, distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

Operation and Maintenance

18. SUPPLEMENTARY NOTES

This project was accomplished as part of the U.S. Army's Pollution Abatement Program D048. The primary objective of this program is to provide, through R&D efforts, cost-effective techniques, processes and systems to aid in achievement of the Army's goal in environmental protection and enhancement.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Present Value Analysis	Uncertainty Analysis	Carbon Adsorption
Present Value-Unit Cost	Sensitivity Analysis	UV-Ozone
Uniform Annual Cost	Least-Cost Preference Ordering	
Present Value Economic Model	Munitions Manufacturing (Pink) Wastewater	
Discounting	Capital and O&M Costs	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This study reviewed and analyzed the procedures, assumptions, economic factors, and the research capital and O&M cost data used by two separate investigators in arriving at their respective least-cost preference ordering of munitions manufacturing (pink) wastewater treatment technologies through present value analysis. Estimated present value cost differences were identified and a reconciliation of these differences was conducted for three alternative

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20. ABSTRACT (Continued)

technologies: Carbon Adsorption with Thermal Regeneration; without Regeneration; and, UV Ozone.

EXECUTIVE SUMMARY

The objectives of this task were to investigate the causes of the differences between the present value cost estimates reported separately in earlier studies by V. J. Ciccone & Associates, Inc., (VJCA) and Large Caliber Weapons Systems Laboratory (LCWSL); to reconcile these differences; and, to determine whether the identical least-cost ordering of three pink wastewater treatment technologies (Carbon Adsorption with Regeneration, Carbon Adsorption without Regeneration, and Ultra-violet Ozone) reported by the two separate investigators would be changed by the reconciliation.

Present value analysis can show either or both of two cost figures: Present Value-Unit Cost (PVUC) and/or Uniform Annual Cost (UAC). The PVUC reports a cost per unit of product in some future year expressed in a base year's dollar values. The UAC converts the total net discounted project lifetime cost into an equal annual cost figure for each of the operating years of the project rather than a present value unit cost.

Since VJCA based its least-cost ordering on PVUC's, and LCWSL based its ordering on UAC's, comparing the two figures exaggerated the differences. When calculations of each other's PVUC's or UAC's were completed and each compared to the other, differences narrowed substantially.

Remaining differences in present value cost estimates were found to be due to either (a) different discount factors applied by each investigator; (b) differences in originally-researched capital, and operating and maintenance cost data; (c) different basic assumptions necessary for present value analysis used by the investigators; and (d) differences in calculating procedures. In one case, (Carbon Adsorption with Thermal Regeneration), economies of scale in the much larger LCWSL plant design (600k/GPD) were found to be a factor in the differences when costs were estimated for both analyses on a smaller VJCA design basis (100k/GPD).

The findings and conclusions of this study are:

By calculating and comparing the same present value measurements, by recalculating present value estimates after eliminating differences in assumptions, and by applying similar computational techniques and procedures, differences were accounted for and reduced from what originally appeared to be LCWSL estimates of almost twice the costs calculated by VJCA for two of the

three technologies and a quarter higher for the third, to estimates that are only about 8 percent and 12 percent higher than VJCA's in two and a reversal of the third from a quarter higher to a quarter lower than VJCA's estimate.

After conducting sensitivity tests for cost data differences and discount rates, the conclusions of this study are that: (a) present value cost estimates, when recalculated with similar assumptions and by the same procedures, were not materially apart from one another; and (b) the originally-reported identical least-cost ordering arrived at individually by LCWSL and by VJCA was not changed by the reconciliation.

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1.0 INTRODUCTION

1.1 BACKGROUND

In February 1982, V. J. Ciccone & Associates, Inc., (VJCA) completed a report presenting the economic evaluation of munitions manufacturing wastewater (pink water) treatment alternatives using computer simulations based on a Present Value-Unit Cost (PVUC) methodology comparing seven state-of-the-art processes.

Present value analysis facilitates meaningful comparisons of alternatives by converting their estimated future cost figures into costs expressed in values of a given base year -- usually the present year. For example, if future dollar costs are quoted in their actual nominal values for each future year, they would normally reflect the effects of inflation and of the interest those dollar amounts of investments might have earned over the interim years. In this undiscounted form, these dollar figures would have little meaning to analysts attempting to compare future costs from the vantage point of the present. Some discounting function should be carried out to account for the forces acting on money over time so that future costs can be expressed in their base year values. Present value analysis performs this function by taking into consideration the effects of inflation on future costs and the offsetting effects of returns on investments (usually interest) that might have been earned each year over that same time period. When the net total discounted project cost (total present value) is divided by the product output of the process, i.e., per gallon, per thousand gallons, or per million gallons, a present value-unit cost (PVUC) is arrived at.

Another step in present value analysis can be taken to produce what is referred to as a Uniform Annual Cost (UAC). The UAC is arrived at by uniformly spreading the cash flow over the years of actual operation of the plant (that is, excluding the construction years when no processing is taking place) so that the total of each year's uniform annual cost (UAC) is equal to the net total discounted project cost described above. The UAC is calculated by simply dividing the net total discounted project cost by the cumulative project year discount factor (for the discount rate used).

VJCA conducted computer simulations using its existing computer model for the PVUC method of evaluating wastewater facilities which essentially evolved from an earlier version by Ciccone[1] and Morgan.[2] This program is an interactive format in Micropolis Extended BASIC (Micro-BASIC) and is run on a Vector Graphics Micronet II system.

The VJCA-PVUC methodology allows treatment unit costs to be calculated on a "systems" basis thereby accounting for all of the major system processes and components. Preliminary designs for daily flows of 10^5 and 10^6 gallons per day (GPD) were prepared to include flow diagrams and data sheets for each alternative treatment system.

Capital and operating costs were obtained from published and unpublished sources in that analysis, adjusted to reflect December 1980 dollars, and converted to functions suitable for use in the computerized PVUC model.

Computer simulations which compared the seven alternatives in various combinations with each other were conducted. The results were tabulated to yield a relative ranking of the feasible alternatives on the basis of the PVUC values. In the study, the following ranking of alternatives was obtained:

a) granular carbon with thermal regeneration;
b) granular carbon with no regeneration;
c) surfactant complexing;
d) powdered carbon with atomized suspension technique (AST) regeneration;
e) ultraviolet-ozone;
f) liquid/liquid extraction;
g) ultrafiltration.

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(1) V. J. Ciccone, et al., "A Present Value-Unit Cost Methodology for Evaluating Wastewater Reclamation and Direct Reuse," Water Resources Bulletin, Vol. II, No. 1, 1975.

(2) J. M. Morgan, Jr., V. J. Ciccone and J. E. Martin, Economic Evaluation of Munitions Manufacturing Wastewater Treatment Alternatives Using a Present Value-Unit Cost Methodology, prepared for U.S. Army Mobility Equipment and Development Command, Ft. Belvoir, VA, Contract No. DAAK70-C-0052, February 1980.

By applying the Present Value-Unit Cost method, the study evaluated the relative economic advantages of seven different alternatives used to remove TNT constituents from wastewaters of the explosive manufacturing and certain LAP operations. The evaluation focused upon a comparison of the calculated costs of alternative treatment methods in proposed full-scale treatment facilities with capabilities of 10^5 GPD and 10^6 GPD, with each facility-plant having an economic life of 30 years.

The PVUC's for six 5-year horizons over the full 30-year life of the plants for each alternative formed the basis for the ranking of the six processes with the first-ranked alternative representing the preferred (least cost) process.

In conjunction with the VJCA study, Large Caliber Weapons Systems Laboratory (LCWSL) presented its present value cost anlaysis of the same treatment processes. While the results of the two, separately-conducted, economic analyses showed the same preference (least-cost) ordering of the processes, they differed in magnitudes of the apparent cost results. Consequently, a reconciliation of the different cost results and the methodologies used to calculate costs computed by VJCA and LCWSL for three technologies, (a) Carbon Adsorption without Regeneration, (b) Carbon Adsorption with Thermal Regeneration, and (c) UV-Ozone, were requested.

The present value costs at the tenth year horizon originally reported by VJCA and by LCWSL in their separate analyses of the three technologies to be reviewed in this report were:

TENTH YEAR NET PRESENT VALUE COSTS/1000 GALLONS*

Alternative	VJCA	LCWSL	Ratio VJCA / LCWSL
a. Carbon Adsorption with Thermal Regeneration			
PVUC	$ 2.20		
UAC		4.37	.50
b. Carbon Adsorption with no Regeneration			
PVUC	$ 2.70		
UAC		5.10	.53
c. UV-Ozone			
PVUC	$ 9.00		
UAC		11.42	.79

Note: See Section 3.4 of this report for a discussion of UAC figures.

* As originally presented by VJCA and LCWSL in their respective studies.

2.0 OBJECTIVES

The objectives of this study were to:

a) Identify sources and document methodology used by VJCA and LCWSL to perform their respective present value analyses.
b) Identify the reasons for the differences between the costs generated by the two methodologies.
c) Examine the impact of the remaining differences between the findings of VJCA and LCWSL, when computation methodologies and analytical assumptions are equalized.
d) Calculate the ratios between the recomputed VJCA costs and the LCWSL costs per 1000 gallons processed at the end of the tenth year of operations (economic life).
e) Collate and tabulate the results of the ratios.

3.0 TECHNICAL APPROACH AND INVESTIGATION PROCEDURES

3.1 DISCUSSION MEETINGS

On July 27, 1982, a contract discussion meeting was held with J. Klein, USATHAMA, and E. Radoski, MERADCOM, to outline the task objectives and the review and report schedule. At this meeting, preliminary and partial cost data and sources used by LCWSL in its analysis were presented to VJCA. In addition, approaches to the reconciliation study to be conducted by VJCA were explored and discussed.

On August 25, 1982, a visit was made to LCWSL, Dover, New Jersey, by VJCA analysts to discuss sources, approaches, methodologies used, and results obtained by LCWSL analysts in their computation of discounted costs for the various technologies analyzed in the original study by VJCA.

Another discussion meeting with J. Klein and E. Radoski was held on September 6, 1982. At this meeting, preliminary findings and potential outcomes were presented by VJCA based on the analysis completed as of that date.

3.2 EXAMINATION OF ANALYTICAL ASSUMPTIONS

As in all economic analyses, and especially in those dealing with long-term projections, certain basic assumptions must be made upon which the analysis is based. Therefore, as an element of this investigation, assumptions and conditions serving as the basis for the LCWSL analysis were identified and compared with those used by VJCA in its PVUC analysis. As expected, the numerous assumptions necessary for a PVUC analysis included many applied by LCWSL which differed from those applied by VJCA. Therefore, wherever possible, these assumptions were tested for sensitivity, and weights (expressed in direction of impact and general magnitude) were assigned to each. In addition, assumptions were made comparable as a test to determine if differences in results would narrow substantially.

3.3 IDENTIFYING BASIC COST DATA DIFFERENCES

Data and data sources, as well as the VJCA PVUC computer data source inventory and assigned functions, were reviewed and checked for applicability and comparability with those used by LCWSL. Where possible, adjustments were made and computations with adjusted data were conducted to measure impact of the differences. Although absolute differences in initial capital and/or annual recurring operation and maintenance costs existed, these cost differences were treated as lump-sum amounts with no attempt made to reconcile differences in the many smaller component parts. Since among the component parts, differences existed in both directions (some higher, others lower), they tended to cancel out in many cases. Thus, analyses were conducted using the aggregate costs of the capital investment and of recurring operation and maintenance activities.

3.4 IDENTIFYING DIFFERENCES IN PVUC AND UAC COMPUTATIONS

In economic analyses of investments and costs incurred over time, two present value measures can be utilized to compare alternatives. One, the Present Value-Unit Cost (PVUC) measure, discounts annual recurring costs (both investments for capital equipment and operation and maintenance costs) for two forces: (1) the time value of money -- usually interest, and (2) the eroding effects of inflation, thereby expressing those future costs on a per unit basis in terms of the basic year's dollar values. The other, the Uniform Annual Cost (UAC), is another calculation of present value which is arrived at by spreading costs uniformly over the years of operating so that the total of all UAC's add up to the total net present value (the sum of all discounted annual costs minus the discounted salvage value of the capital equipment). Since the UAC and the related PVUC come from the same present value data, they maintain their relationship among alternatives as long as economic lives of the alternatives being compared are the same. Therefore, use of either the PVUC or the UAC figure can serve as the basis for the ordering of the alternatives.

In the original study, VJCA computed Present Value-Unit Costs per million gallons processed but did not calculate Uniform Annual Costs since the project

lives of the alternative measured were the same. On the other hand, LCWSL computed Uniform Annual Costs per 1000 gallons processed but did not indicate the Present Value-Unit Costs these data would have produced. Therefore, it used UAC's as the basis for its ordering of alternatives even though the project lives of the alternatives examined were the same.(1)

After identifying these differences in the analyses, appropriate factors and computational procedures were applied to compute both the PVUC's and the UAC's for the VJCA and the LCWSL computations. These two values for each technology restudied were then compared to determine actual differences between VJCA and LCWSL present value cost calculations and the sources of any remaining discrepancies.

3.5 THE RECONCILIATION PROCESS

After all differences were identified and given a weight (reflecting size and direction of change), the reconciliation process was carried out for three different technologies: (1) Carbon Adsorption with Thermal Regeneration, (2) Carbon Adsorption without Regeneration, and (3) UV-Ozone. This process consisted of:

a) Computing PVUC and UAC using VJCA data in LCWSL procedures and noting the narrowing of the differences in the related PVUC's and UAC's.
b) Computing PVUC and UAC using LCWSL data in the VJCA computer model and noting the narrowing of the differences in the resultant PVUC and UAC.
c) Computing PVUC and UAC using VJCA model after adjusting the LCWSL data to a 100,000 GPD flow rather than its original 600,000 GPD flow (to test for loss of economies of scale).

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(1) According to NAVFAC P-442 Economic Analysis Handbook, "UAC is a useful tool only in cases of unequal economic lives. If alternatives have the same economic life, computation of equivalent annual costs is a superflouous exercise, which, although not incorrect, generates no new useful information." July 1980, p. 41.

As the final phase of the reconciliation process, ratios of the newly calculated PVUC's and UAC's for the LCWSL and the VJCA analyses were computed and listed for each of the three alternative technologies. Causes for the remaining differences, however slight, were identified.

4.0 DISCUSSION

4.1 COMPARING PRESENT VALUE MEASUREMENTS WITH EACH OTHER NARROWS THE DIFFERENCE

Since the VJCA study computed only the PVUC for each alternative technology as a basis for its ordering, while the LCWSL work computed only the UAC of each technology analyzed, differences between the two analyses were not as large as they first appeared when both PVUC's and UAC's for each technology were computed and compared. Comparing PVUC's and UAC's of VJCA with PVUC's and UAC's of LCWSL narrowed the differences substantially.

4.2 REMAINING DIFFERENCES NARROW EVEN FURTHER AFTER APPLYING COMPARABLE ASSUMPTIONS AND COMPUTATION TECHNIQUES

Because numerous LCWSL assumptions and computational procedures differed from those used by VJCA in its analyses, and because some differences in capital costs and recurring annual operating and maintenance costs existed (many with offsetting effects), actual PVUC and UAC figures computed by VJCA and LCWSL were not absolutely the same. However, after applying comparable assumptions and eliminating differences in computational techniques, differences in PVUC's and UAC's narrowed even further. The ultimately calculated ratios (VJCA/LCWSL) for the 2 percent discounting were as follows:

	Reconciled PVUC Ratio	Original PVUC-UAC Ratio
a) Carbon Adsorption with Thermal Regeneration	92	.50
b) Carbon Adsorption without Regeneration	89	.53
c) Ultraviolet Ozonolysis (UV Ozone)	1.26	.79

The remaining differences (-8 percent, -11 percent and plus 26 percent for VJCA calculations) were largely the result of differences between VJCA's and LCWSL's basic capital and/or recurring annual cost data.

4.3 EFFECTS OF DIFFERENT DISCOUNT FACTORS

The factor accounting for a large part of the original differences in UAC results (but not in PVUC's) was the different discount factors used by LCWSL and by VJCA. VJCA discount factors were based on a 2 percent real rate of return while LCWSL used a set of discount factors taken from a DoD calculated table based on a 10 percent real rate of return. When discount factors are based on higher discount rates as in the LCWSL analysis, UAC figures differ substantially with PVUC figures for the same technology; when discount factors are based on lower discount rates as in the VJCA analysis, the difference between UAC's and PVUC's tend to narrow.(1)

4.4 COST DATA DIFFERENCES AND DIFFERENT DISCOUNT RATES DID NOT CHANGE ORIGINAL PREFERENCE ORDERING OF ALTERNATIVES

Adjusted cost differences (both PVUC and UAC), where they existed, did not affect the initial ordering of the technologies constructed by either VJCA or by LCWSL. Since the purpose of the initial contract was to construct such a preference ordering, whether that ordering was based on lower or higher magnitudes of PVUC's (either discounted at 2 percent or at 10 percent) did not affect the outcome. A sensitivity analysis of the inflation factor was conducted to test its effect over time. This analysis confirmed that although cost magnitudes would increase at lower discount rates (higher inflation rates), they would not change the preference ordering of the alternatives. (See Appendix E-1.)

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(1) The 2 percent discount rate used by VJCA in its analysis is based on its estimate of a lower <u>real</u> rate of return; that is, a rate of return on capital investments eroded by a rate of inflation significantly higher than the long-term average used by DoD. See Section 6.11 of this report for data and rationale used by VJCA as a basis for its 2 percent discount rate rather that DoD's calculated table of 10 percent discount factors.

5.0 PVUC ECONOMIC ANALYSIS VERSUS THE BUDGET PROCESS[1]

5.1 PVUC ECONOMIC ANALYSIS

PVUC methodology facilitates meaningful comparisons between and among alternative systems. In this type of analysis, estimated future costs, both initial capital investments (e.g., construction costs) and annually recurring operation and maintenance costs,[2] are converted into equivalent costs expressed in present dollar values.

To facilitate understanding PVUC analysis, two forces acting upon values over time should be mentioned. First, since there is a time value associated with money (i.e., an invested dollar is worth more 10 years from today than five years or one year from today), this return on money, usually identified as interest or rate of return from investments, should be considered when analyzing investments especially those requiring expenditures at various points in time in the future.

At the same time, the purchasing power of money is usually eroded by inflation over the project life span. Therefore, in order to convert future outlays into equivalent present values (converting the dollar expenditures made in the future into the values those dollars have today), two functions must be performed. First, costs must be escalated to a level expected for that future point in time, and second, they must be discounted to take account of the time value of money.

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(1) Explanation of PVUC economic analysis presented here is based on Economic Analysis Handbook, NAVFAC P-442, July 1980 issue, compiled by the Navy Facilities Engineering Command, Alexandria, Virginia, consistent with DoD Instruction (DOD INST) 7043.3 series, entitled "Economic Analysis and Program Evaluation for Resource Management."

(2) In economic analysis, cost estimates are best judgments of the expected future cash flows. Future costs, salvage values, economic life, and other factors such as future interest rate levels (or rates of return on investments) and inflation, are all estimated based on some reasonable judgment.

PVUC analysis performs these functions simultaneously through the use of discount factors calculated by adjusting the expected rate of return on the investments for the effects of inflation. This "real" rate of return is inserted in the following equation as i:

$$PV = I_n \frac{1}{(1+i)^n} \quad *$$

The real rate of return (i) which is the basis for computing the discount factors applied in future operating years is taken into account whether the investor is an individual, a corporation, or the government. Since government investments are funded with money taken from the private sector (mainly through taxation) and are made in the ultimate behalf of the public, government investments bear an implicit rate of return comparable to that of projects undertaken in the private sector. However, since this rate of return is not earned by the government on its investments, the real rate of return measures the opportunity cost of investments foregone by the private sector.

5.2 THE BUDGET PROCESS

PVUC economic analysis has a highly specific objective which differs markedly from analyses performed for future budgeting of an activity, a program, or an operating plant. Although many of the conditions and judgments made and used in PVUC analysis which are assumed to impact on costs over time are useful in a budget process, the dollar values in PVUC analysis are, in a

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* Where:

PV = present value or cash equivalent in today's dollars.

I_n = the dollar amount of a cash flow occurring in n years in the future.

i = the discount rate.

Since the quantity within the brackets is less than unity, it reduces the future cash flow into its present value equivalent PV. The quantity within the bracket is therefore referred to as a "discount factor".

sense, a mirror image of the costs, expressed in estimated future dollar values, in a long-term, best judgment budget program. For one, the stream of constant dollar annual costs (that is, equal annual cost amounts) used in the cash flow of PVUC analysis does not represent budgetary outlays during the project years, since in reality and for several reasons, these costs would probably be non-uniform. However, the constant dollar stream in PVUC analysis represents a best estimate of the average annual costs over the time period. Furthermore, in budgetting, these costs would be escalated forward to account for increasing prices, higher wages, and contingency expenditures at various points in the project's life cycle. In budgetting, only operating expenditures and receipts (or benefits) are considered; depreciation of capital assets, salvage values, and discounting for interest are not part of that process but are included elsewhere in the accounting function. Thus, in budgetting (usually a short-term process), all actual annual costs are estimated and then escalated by an inflation factor either forecasted elsewhere or estimated. In PVUC analysis for government projects (usually a long-term analysis), outlays and costs, including depreciation values of capital assets, foregone interest income (or opportunity costs), and inflation effects, are all netted out against each other over time and then discounted back to the present in order to translate those dollar values out in time to dollar values existing at the present (or some base year). In summary, the PVUC results represent an analytical tool useful for comparing alternatives by examining future costs in today's values so that a reasonable choice between them can be made based on least-costs. Budgeting, on the other hand, utilizes a process to estimate costs in future values in order to establish nominal (undiscounted) amounts for operating budgets or budget requests.(1)

(1) NAVFAC P-442, Economic Analysis Handbook, July 1980, pp. 54 and 112.

6.0 ELEMENTS OF PRESENT VALUE ECONOMIC ANALYSIS AFFECTING OUTCOMES

There are many elements in present value analysis for which estimates and assumptions could differ between analysts and thereby affect their separately calculated outcomes. In the VJCA and the LCWSL analyses, the following elements (variables) were identified and found to differ, thereby impacting on the present value amounts and/or the uniform annual cost amounts calculated by each for the same technologies studied.

a) Capital (investment) and Operation and Maintenance (annual recurring costs) data.
b) Discount rates applied.
c) Discount computation procedures used.
d) Length of project/economic lives of plants.
e) Plant capacities in gallons per day (GPD).
f) Year in which salvage value was computed.
g) Years over which capital costs were spread.
h) Discounting of capital costs.
i) Lead times before operation and maintenance costs (annual recurring costs) commenced (the start of the "economic life" of the project).
j) Base year to which originally-researched cost data were adjusted.

6.1 CAPITAL, AND OPERATION AND MAINTENANCE COST DATA

Cost data for both capital (investment) and operation and maintenance (O&M) differed in VJCA analyses as compared to LCWSL analyses. However, since VJCA's analysis involved plants with a 100,000 GPD capacity flow and LCWSL's analysis applied to plants with a 600,000 GPD capacity flow, cost differences (some higher, some lower) were not as substantial when adjusted to similar 100,000 GPD capacity flows. While some economies of scale were evident in the larger 600,000 GPD design for the Carbon Adsorption with Thermal Regeneration plant considered by LCWSL, when adjusted down to 100,000 GPD, the loss of these economies was highly evident. When initial investment (capital) costs differed, they were not as influential in affecting outcomes as were annual recurring costs because of the one-time, first-year (little, if any,

discounting) nature of these capital costs. On the other hand, where annual recurring costs differed, the fact that the annual differences were repeated for every year magnified their impact considerably during the mid and later years of the 30-year life plants.(1)

6.2 DISCOUNT RATE

The discount rate used by VJCA was 2 percent and discount factors were calculated by VJCA based on that rate. In the LCWSL analysis, discount factors published by DoD based on a 10 percent real discount rate were used. The lower 2 percent discount rate produces smaller factors, which, when multiplied by the original costs, discount at a much slower pace each year. Thus, the total discounted project costs are at higher values because initial amounts are not discounted as much as in 10 percent discounting. But since discounted salvage values are also higher for 2 percent discounting (for the same reason) they offset much of the discounted project costs. Therefore, when the greater O&M discount factors of a 10 percent discount rate are used, as they were in the LCWSL analyses, not much difference occurred in PVUC's of VJCA and LCWSL. But, UAC's computed by LCWSL with the 10 percent factors were almost twice as high as they were when VJCA used the 2 percent discount factors. (See Section 6.11 for data and rationale used by VJCA as a basis for its 2 percent discount rate.)

6.3 DISCOUNT COMPUTATION PROCEDURES USED

Discounting can be computed using one of two procedures: (a) a "Continuous Compounding" technique in which it is assumed cash flows occur throughout the year rather than in one lump sum at either the beginning or end of the year. The DoD tables are constructed using a "Continuous Compounding"

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(1) See Appendix D of this report for results of a sensitivity analysis of capital and O&M costs.

technique. It is simulated in those tables by computing annual mid-year factors for each year rather than end-of-year factors; or (b) a "Discrete Cash Flow" procedure which assumes a lump sum payment rather than smaller payments throughout the year as in "Continuous Compounding". In these cases, factors are somewhat larger with the resulting difference between the two procedures, although minor, raising the PVUC result when a "Discrete Cash Flow" procedure is applied.

6.4 LENGTH OF PROJECT/ECONOMIC LIVES OF PLANTS

In conceiving the basic design of the plant involved in the technology, an assumption must be made as to the number of years the whole project will take (planning, engineering, design, plus construction time and the number of operating years = total project time). For example, if it takes two years to plan, design and construct the plant, then the "operation" is assumed to commence in the third year. In this case, the economic life of the plant (the life in which benefits are to be derived from the operation of the plant) commences at the beginning of the third year.

On the other hand, if all pre-operating activities are completed in the first year with an immediate cash outlay made at the start of the year, the economic life (when O&M cost start) commences at the beginning of the second year.

It is important to point out that the difference in the above conditions effects the discounting factors to be applied. When capital costs are spread over two years, these costs, split over the two years, are discounted in each year since the forces of rate of return and inflation affect each capital outlay from the start of the base year. In the other procedure, if the pre-operation activities are completed in one and the outlay for that capital investment is made at the beginning of that year, then there is no discounting of that total capital investment. In this case, the first discount factor is applied in the second year (the beginning of the economic life), while in the extended capital approach, the first discount factor is applied in the first year and by the time the recurring annual costs commence, the discount factor is in its third year.

In the LCWSL analysis, "Continuous Compounding" is used and the capital investment is spread over two years with recurring O&M costs discounting starting with the third year discount factor.

In the VJCA analysis, "Discrete Cash Flow" is used here, capital investments are, for purposes of analysis, made at the beginning of the first year in one lump sum, and therefore capital costs are not discounted at all. Recurring O&M costs start to be discounted with a first year discount factor in the year following the capital investment year (which is actually the start of the projects "economic" life).

These three differences (project life, economic life, and discounting procedures) tend to raise the PVUC of the VJCA analysis, but even when taken together, these values rise only slightly.

6.5 PLANT CAPACITIES IN GALLONS PER DAY (GPD)

The capacity flow design of the plant analyzed certainly has an effect on ultimate PVUC values, but only to the extent that economies of scale are inherent in the higher flow design. (Since PVUC and UAC are ultimately reported in dollars per 1000 gallons, the larger flow capacity should not generate a difference in present values as long as economies of scale are not present).

LCWSL based its analyses on plants with a flow capacity of 600,000 GPD for carbon adsorption (no regeneration) and carbon adsorption (thermal regeneration) technologies while VJCA computed costs at 100,000 GPD. However, in the thermal regeneration process, economies of scale were present in the LCWSL cost data since its cost of the regeneration process was fixed, and therefore applied in the same amount to both the 100,000 GPD capacity as well as the 600,000 GPD capacity. In this case, when the LCWSL computations were reduced to 100,000 GPD to make the system comparable with the VJCA design for analytical purposes, the loss of the economies of scale was highly apparent as LCWSL's PVUC rose dramatically compared to VJCA's.

In the UV-Ozone analysis, both LCWSL and VJCA based costs on capacity flow rates of 100,000 GPD.

6.6 YEAR IN WHICH SALVAGE VALUE IS COMPUTED

Salvage value of the capital investment (building and plant equipment) is an important factor in netting out the total discounted costs. However, it is only an important factor in the early and mid-years of the plant's life cycle since as the value of the plant decreases equally in each year of its lifetime (for analytical purposes), when discount factors are applied to that value in the later years, the value flattens out considerably. Thus, in the latter years, differences in salvage values affect the PVUC outcomes only minimally.

In this analysis, the PVUC's and the UAC's are calculated at the first 10 years of operation when salvage values are still relatively high. Furthermore, if the discount factors are based on 2 percent (as they are in the VJCA analysis) rather than 10 percent, the discounted salvage value is higher and thus its offset affect on total discounted project costs at that point in time is higher. In turn, this makes the total net discounted project cost (adjusted for salvage value) lower, thereby lowering the PVUC slightly in the VJCA 2 percent procedure.

In computing salvage value, especially while asset values are still high in the tenth year of a 30-year life cycle project, LCWSL includes the two construction years toward the depreciation of the capital asset, while VJCA does not.(1) In addition, rather than base the salvage value on the twelfth year's value (two year build-up + 10 years of operation), LCWSL discounts the salvage value in the thirteenth year. By doing so, LCWSL lowers the salvage value of the building thereby reducing the cost offset to the total discounted costs. The result is a higher net total discounted project cost and, in turn, a slightly higher PVUC value for the LCWSL analysis.

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(1) Depreciation referred to here is not the accounting asset generated in the private sector tax treatment process (by reducing the private firm's tax bill). In this analysis, since no taxes are paid by the government, depreciation is simply a straight-line reduction of the value of the asset over the life span of that asset. It is computed simply to estimate the salvage value of the asset, which because it is out in time somewhere, must be discounted by the appropriate discount factor to convert it into its present value.

6.7 YEARS OVER WHICH CAPITAL (INVESTMENT) COSTS ARE SPREAD

As pointed out in Section 6.4 above (discussing "Length of Project/Economic Lives of Plants"), discounting of capital (investment) costs can occur over one, two or more years depending on the time assumed to plan and build the plant being analyzed. Since discounting of capital costs also affects when and what discount factors are applied to recurring annual costs, the time over which capital costs are spread affects the PVUC outcome somewhat.

LCWSL spread its capital outlays over two years in each of its analyses. On the other hand, VJCA assumed that capital costs were incurred in one year and in one lump sum amount thereby not discounting these costs at all.

The effect (cummulative with capital cost discounting and O&M lead times discussed in the following paragraphs) tends to slightly raise the PVUC in the VJCA procedure.

6.8 DISCOUNTING OF CAPITAL COSTS

In addition to the spread of capital costs, the PVUC can also be affected by the treatment of capital costs during the period of construction; that is, whether these costs are discounted or not, can affect the PVUC outcome. For example, VJCA assumes an initial outlay of capital costs in one lump sum and completion of the construction in one year. It therefore does not discount these investments (the discount factor is 1.000).[1] However, LCWSL not only spreads its capital investments over two years, but starts discounting these investments in the first year, thereby advancing the discount factors by two years for all subsequent annual recurring costs. The effect of the LCWSL procedure is to lower its PVUC slightly over the costs calculated by the VJCA method.

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(1) It should be noted that the DoD procedure as reported in NAVFAC P-442, Economic Analysis Handbook, July 1980, does not discount one-year investments.

6.9 LEAD TIME BEFORE OPERATION AND MAINTENANCE COSTS (ANNUAL RECURRING COSTS) COMMENCE

Again, as mentioned in the preceding two paragraphs, if the capital costs are spread over more than one year, and discounting commences in the first (investment) year, then the elapsed time before the economic life starts (when O&M costs commence and when a benefit from the operation commences) is longer. Therefore, by the time O&M costs are started and discounted, the discount factor is larger than it otherwise would have been without the longer start-up period. The effect is, in combination with the above two effects, to slightly lower the ultimate PVUC for LCWSL and to raise it for the VJCA method.

6.10 BASE YEAR TO WHICH ORIGINALLY-RESEARCHED COST DATA WERE ADJUSTED

When early cost data gathering research is conducted in a PVUC analysis, appropriate cost data for both capital cost and operation and maintenance costs are accumulated. In most cases, these costs will have different sources which often quote cost figures which existed in previous years. Since one of the basic requirements of PVUC analysis is to bring all such researched data to a common base period (year), an appropriate inflation adjustment factor must be applied to data applicable to past years to bring all data to one common base time point. Indices used to adjust such data are either the Bureau of Labor Statistics' (U.S. Department of Labor) Producer Price Index (PPI) or some relevant component of that index, the Consumer Price Index, the Gross National Product Implicit Price Deflator, or the Engineering News-Record (ENR) Building Cost Index.

Although both the LCWSL and the VJCA analyses adjusted their respective intially-researched cost data to a common time base, LCWSL adjusted its data by using the <u>average</u> PPI for the 1980 while VJCA adjust its data by raising the researched costs to <u>December</u> 1980. Although the difference in ultimate inflation-adjusted costs was only slightly affected by the use of these two different adjustment factors, the more current VJCA adjustment index raised its PVUC values slightly over those computed by LCWSL.

6.11 ECONOMIC DATA USED TO CALCULATE THE REAL RATE OF RETURN ON INVESTMENTS

The following data for the years 1974 to and including estimates for 1982, show Corporate AAA Bond interest rates (as a proxy for rates of return on capital investments) and the Implicit Price Deflator for Personal Consumption Expenditures (in annual percentage changes) representing inflation. These data were used by VJCA in arriving at a 2 percent discount rate for its PVUC analysis in place of the DoD factors which are based on a 10 percent discount rate. Since DoD's 10 percent rate represents the difference between a 12 percent rate of return on capital investments in the private sector and a 2 percent average inflation rate for the years 1949 to 1965 measured by the implicity price deflator for Personal Consumption Expenditures, these data for more recent years show a 1.8 percent difference between rates of return and inflation. Thus, VJCA chose to use 2 percent to calculate discount factors in its PVUC analysis.

Year	Bond Rates (Corporate AAA)(1)	Pers. Cons. Exp. Ann. % Change	Real Rate of Return (%)
1974(2)	9.9	10.1	(-0.2)
1975(2)	6.3	7.6	(-1.3)
1976	5.3	5.1	0.2
1977	5.6	5.8	(-0.2)
1978	8.0	7.0	(-1.0)
1979(2)	10.9	9.0	1.9
1980	12.3	10.3	2.0
1981(2)	14.8	8.6	6.2
1982(2)	11.5 (Est.)	5.0 (Est.)	6.5
9-Year Average	9.4%	7.6%	Net Change = 1.8%

(1) The Corporate AAA Bond Interest Rate was used as a proxy for the rate of return on corporate investments.

(2) These years were total or partial recession years in which, for many corporations, rates of return on investments were probably lower than interest rates for Corporate AAA Bonds, in which case the rate of return adjusted for inflation would be even smaller than the 1.8% shown above.

Conclusions:

A. Real rates of return have been considerably lower in the past nine years than they have been for the 1949-1965 period.

B. Recognizing that some monetary and other economic anomalies may have skewed real rates of return downward for the above indicated nine years, it is estimated that for the next decade or so, real rates of return will probably be closer to 3 to 5 percent than the 10 percent recommended by DoD.

7.0 FINDINGS AND CONCLUSIONS

A review of the procedures used by LCWSL, plus a discussion of these procedures with LCWSL personnel disclosed that many of the assumptions used by LCWSL in its analysis differed from those used by VJCA. In addition, several computational differences existed in the present value methodology of VJCA and LCWSL. These elements of present value analysis are discussed in Section 6.0 of this report.

It also should be noted that either one of two present value measurements -- Present Value-Unit Costs (PVUC) or Uniform Annual Costs (UAC) can serve as the basis for a present value least-cost preference ordering of various alternative technologies. In the original cost estimating computations, VJCA used PVUC's while LCWSL used UAC's. Therefore, in this reconciliation process, it was necessary to compute both measurements for each set of data and then compare like measurements in order to better assess existing differences.

Among the differences in the assumptions used by either investigator, a few had large impacts on present value outcomes while others were small in their effect and, in most cases, were offsetting. The major differences found to exist were:

a) LCWSL's use of discount factors based on a 10 percent real rate of return on investments (the difference between an assumed 12 percent rate of return and a 2 percent longterm inflation rate), which are recommended by DoD for present value analysis when other evidence is lacking, and factors based on a 2 percent real rate of return calculated by VJCA (which assumes a higher longterm inflation rate). Although lower real rates of return used by VJCA in its present value analysis tend to raise PVUC's (all other factors held constant), a sensitivity analysis showed that they did not change the least-cost preference ordering of technologies over their lifetime.

b) The effect of LCWSL's 10 percent discount factors was larger on UAC's than it was on PVUC's. When the larger 10 percent real rate was used, UAC's were almost twice as large as they were when the smaller 2

percent rate was the basis for discounting. This accounts for the narrowing of the differences between UAC's calculated from VJCA and LCWSL data at 2 percent discount rates than at the 10 percent rates. Here too, UAC's at either rate did not affect the least-cost preference ordering of the alternative technologies over time.

c) Differences in originally researched cost data for both capital and O&M costs accounted for a large part of the remaining spread between VJCA's and LCWSL's computed present value costs. However, it was found that, although differences in original capital cost data existed, their impacts were proportionately less than the differences in O&M costs. Thus, when O&M costs differences were large for a technology, as in the case of UV Ozone, the effects on present value estimates were larger and differences were greater. This accounts for the relatively large remaining 26 percent difference in reconciled present value estimates for UV Ozone as compared to only 8 percent for Carbon Adsorption with Thermal Regeneration and 11 percent for Carbon Adsorption without Regeneration.

d) Comparisons of differences in original estimates of PVUC's and UAC's and those resulting from this reconciliation task are:

VJCA ORIGINAL ESTIMATES		RECONCILED ESTIMATES VJCA	RECONCILED ESTIMATES LCWSL	LCWSL ORIGINAL ESTIMATES	
1. Carbon Adsorption with Thermal Regeneration					
$2.20	PVUC	$2.54	$2.75	PVUC	-
-	UAC	$2.83	$3.06	UAC	$4.37
2. Carbon Adsorption without Regeneration					
$2.70	PVUC	$2.81	$3.15	PVUC	-
-	UAC	$3.12	$3.51	UAC	$5.10
3. Ultraviolet Ozonolysis					
$9.00	PVUC	$9.23	$7.32	PVUC	-
-	UAC	$10.28	$8.15	UAC	$11.42

Expressed in VJCA/LCWSL ratios (with 1.00 representing no difference between a VJCA and LCWSL present value cost estimate), the following table indicates that differences narrowed considerably.

	Original PVUC-UAC Ratios	Reconciled PVUC Ratios
1. Carbon Adsorption with Thermal Regeneration	.50	.92
2. Carbon Adsorption without Regeneration	.53	.89
3. Ultraviolet Ozonolysis	.79	1.26

Conclusions arrived at in this study are:

a) Original apparent differences between present value estimates of the three technologies examined were much smaller when similar present value analysis techniques and assumptions were applied in the analysis.

b) Although magnitudes of present value cost estimates changed, the original least-cost preference ordering reported by both VJCA and LCWSL in their respective original reports was not affected by this reconciliation process.

c) Present value analysis is a highly useful procedure to facilitate meaningful comparisons between and among alternative systems; however, if conducted by different examiners for essentially similar capital projects, a thorough understanding of the present value process and its uses must prevail. Equally important, in these situations, a common set of standards of procedure and a matching of reasonable assumptions must be provided each examiner, and prior agreement to use these standards and assumptions must exist in order to avoid different and confusing results.

8.0 RECONCILIATION CALCULATIONS

Other than the capital, and operation and maintenance cost data differences and the up-dating for inflation to different base periods, the identified differences were based, by and large, on judgments, and thus, these judgmental differences between assumptions made by each analyst could have been eliminated by agreement between the analysts (in effect, setting common analytical ground rules). Consequently, in this reconciliation process, wherever possible, differences in assumptions were eliminated to establish a common footing from which the PVUC and UAC analyses could proceed. In this way, remaining differences in the outcomes, if any, would be more easily identified, and associating differences with causative factors would be less difficult to make.

In the following section, results of present value cost calculations performed by both LCWSL methods and VJCA computer model runs, using either LCWSL data or VJCA data, under various conditions adjusted for comparability purposes, are shown in a summary table for each technology.

The following tables summarize the calculations performed in related tables in the Appendices to this report. Several sets of cost estimates are included in each of the three summary tables. Each set of estimates represents the results of various adjustments made to the reconciliation process. The final set in each summary table shows present value cost estimates calculated under the most comparable assumptions and conditions. Ratios for each set are also indicated to highlight the narrowing of cost differences as adjustments are made.

8.1 RECONCILIATION FOR CARBON ADSORPTION WITH THERMAL REGENERATION

TABLE 1

PVUC/UAC RATIOS

CARBON ADSORPTION WITH THERMAL REGENERATION

(At 10-Year Horizons)

($ Per 1000 Gallons)

SEE APPENDIX

TABLE NO.	VJCA ORIGINAL @ 2%	LCWSL ORIGINAL @ 10%	RATIO VJCA/LCWSL
2	PVUC $2.20	PVUC ..... $2.33(1)	.94
	UAC ..... 2.47(1)	UAC 4.37	.56
	VJCA ORIGINAL (CORRECTED) @ 2%	LCWSL ORIGINAL @ 10%	
3	PVUC $2.54	PVUC ..... $2.33(1)	1.09
	UAC 2.83	UAC 4.37	.65
	VJCA DATA @ 10% - VJCA METHOD	LCWSL ORIGINAL @ 10%	
4	PVUC $2.94	PVUC ..... $2.33(1)	1.26
	UAC 4.79	UAC 4.37	1.10
	VJCA DATA IN LCWSL FORMAT @ 2%	LCWSL ORIGINAL @ 2% LWCSL METHOD	
5	PVUC $2.49	PVUC ..... $2.33(2)	1.07
	UAC 2.83	UAC 2.64	1.07
	VJCA ORIGINAL (CORRECTED) @ 2%	TO 100K GPD - VJCA METHOD @ 2%	
6	PVUC $2.54	PVUC $2.75	.92
	UAC 2.83	UAC 3.06	.92

(1) PVUC's not computed in original LCWSL computations. UAC's not computed in original VJCA computations.

(2) The same PVUC amount for LCWSL's 10% calculations (in #1,2,&3) as the 2% calculations (in #4 above) is merely coincidental; other differences in the two calculations were offsetting.

8.2 RECONCILIATION FOR CARBON ADSORPTION WITHOUT REGENERATION

TABLE 7

PVUC/UAC RATIOS

CARBON ADSORPTION WITHOUT REGENERATION

(At 10-Year Horizons)

($ Per 1000 Gallons)

SEE APPENDIX

TABLE NO.	VJCA ORIGINAL @ 2%	LCWSL ORIGINAL @ 10%	RATIO VJCA/LCWSL
8	PVUC ..... $2.70 UAC ..... 3.04(1)	PVUC ..... $2.72(1) UAC 5.10	.99 .60
	VJCA ORIGINAL (CORRECTED) @ 2%	LCWSL ORIGINAL @ 10%	
9	PVUC ..... $2.81 UAC 3.12	PVUC ..... $2.72(1) UAC 5.10	1.03 .61
	VJCA DATA @ 10% - VJCA METHOD	LCWSL DATA @ 10% - VJCA METHOD ADJUSTED TO 100K GPD	
10	PVUC ..... $2.30 UAC 3.74	PVUC ..... $2.87 UAC 4.67	.80 .80
	VJCA ORIGINAL (CORRECTED) @ 2%	LCWSL ORIGINAL @ 2% VJCA METHOD	
11	PVUC ..... $2.81 UAC 3.12	PVUC ..... $3.17(1) UAC 3.53	.89 .89
	VJCA ORIGINAL (CORRECTED) @ 2%	LCWSL ORIGINAL @ 2% - VJCA METHOD ADJUSTED TO 100K GPD	
11	PVUC ..... $2.81 UAC 3.12	PVUC ..... $3.15(2) UAC 3.51	.89 .89

(1) These figures were not computed in the original analyses.

8.3 RECONCILIATION FOR ULTRAVIOLET OZONOLYSIS

TABLE 12
PVUC/UAC RATIOS
ULTRAVIOLET OZONOLYSIS (UV OZONE)
(At 10-Year Horizons)
($ Per 1000 Gallons)

SEE APPENDIX

TABLE NO.	VJCA ORIGINAL @ 2% 30-YEAR LIFE	LCWSL ORIGINAL @ 10% 15-YEAR LIFE	RATIO VJCA/LCWSL
13	PVUC .....$ 9.00 UAC ..... 10.27(1)	PVUC .....$ 6.09(1) UAC 11.42	1.48 .90
	VJCA ORIGINAL (CORRECTED) @ 2%, 30-YEAR LIFE	LCWSL ORIGINAL @ 10% 15-YEAR LIFE	
14	PVUC .....$ 9.23 UAC 10.28	PVUC .....$ 6.09(1) UAC 11.42	1.51 .90
	VJCA DATA @ 10% - LCWSL METHOD, 15-YEAR LIFE	LCWSL ORIGINAL @ 10% 15-YEAR LIFE	
15	PVUC .....$ 6.46 UAC 12.12	PVUC .....$ 6.09(1) UAC 11.42	1.06 1.06
	VJCA ORIGINAL (CORRECTED) @ 2%, 30-YEAR LIFE	LCWSL ORIGINAL @ 10% 30-YEAR LIFE	
16	PVUC .....$ 9.23 UAC 10.28	PVUC .....$ 5.77 UAC 10.83	1.60 .94
	VJCA ORIGINAL (CORRECTED) @ 2%, 30-YEAR LIFE	LCWSL DATA - VJCA METHOD @ 2%, 30-YEAR LIFE	
17	PVUC .....$ 9.23 UAC 10.28	PVUC .....$ 7.32 UAC 8.15	1.26(2) 1.26(2)

(1) These figures were not computed in the original analyses.
(2) The higher PVUC and UAC figures for VJCA analysis under essentially similar conditions as the LCWSL analysis are for the most part accounted for by the Net Total Discounted Costs (Capital costs + Total O&M recurring costs, less the discounted salvage value). For VJCA, capital costs are $432,000 less than LCWSL's capital costs. At the same time, VJCA's annual recurring O&M costs are $98,000 a year (or $980,000 over the 10 years) more than LCWSL's O&M costs. Thus, the net difference in the Net Total Discounted Costs between the VJCA data and the LCWSL data is +$664,000 for VJCA over the 10 years. This rather large cost difference (at discounted amounts) causes the VJCA Present Value figures to be approximately 25% to 26% higher than LCWSL's analysis.

APPENDIX A

RECONCILIATION TABLES FOR CARBON ADSORPTION WITH THERMAL REGENERATION

TABLE NO. 2*, 2(a), 2(b)
TABLE NO. 3*, 3(a), 3(b)
TABLE NO. 4*, 4(a), 4(b)
TABLE NO. 5*, 5(a), 5(b)
TABLE NO. 6*, 6(a), 6(b)

* Summary tables showing the differences between VJCA and LCWSL costs, discount rates, assumptions and calculating procedures for the process shown. PVUCs and UACs arrived at in the related calculation tables under the stated conditions, and the VJCA/LCWSL cost ratios are shown in lines 11 and 12 of the Summary Tables.

TABLE 2

SUMMARY

PVUC ANALYSIS RECONCILIATION

PROCESS: CARBON ADSORPTION WITH THERMAL REGENERATION

LCWSL - VJCA

($ in Millions)

At Ten-Year Horizons

PROCEDURE: VJCA ORIGINAL @ 2% - LCWSL ORIGINAL @ 10%

		VJCA	LCWSL	
1.	Cost Data:			
	Capital Costs	.974	3.824	
	O&M Costs	.050	.362	
2.	Discount Rate	2%	10%	
3.	Discount Comp	D.D.F.(2)	C.C.(2)	
4.	Project Life	31 yrs.	22 yrs.	
	Economic Life	30 yrs.	20 yrs.	
5.	Plant Cap/GPD	100,000	600,000	
6.	Salvage Value Year	10th	13th	
7.	Capital Cost Yr. Spread	1 yr.	2 yrs.	
8.	Capital Cost Discount	None	2 yrs.	
9.	Lead Time to O&M	1 yr.	2 yrs.	
10.	Base Period (Costs)	Dec 1980	Avg. 1980	
11.	PVUC/k gals.	$2.20	$2.33(1)	Ratio .944
12.	UAC/k gals.	$2.47(1)	$4.37	.565

Note: (1) These figures were not computed in the original analyses.
(2) D.C.F = Discrete Cash Flow; C.C. = Continuous Compounding.

TABLE 2(a)

COMPUTER OUTPUT 3.1.3.1a
PRESENT VALUE UNIT COST ANALYSIS
COMPARING TREATMENT A (CARBON: NO REGENERATION (0.652 LBS INT/LB C))
WITH TREATMENT B (CARBON: THERMAL REGEN. (0.052 LBS INT/LB C)).
SYSTEM LIFESPAN TO BE 30 YEARS WITH 350 OP. DAYS PER YEAR.
ANALYSES ARE OVER FIVE YEAR SPANS (OR 'HORIZONS').

TOTAL CAPITAL COSTS FOR ALTERNATIVE A = $ 307750 AND FOR ALTERNATIVE B = $ 974080;
RATIO OF CAPITAL COSTS OF B TO CAPITAL COSTS OF A = 3.16; INTEREST RATE = .15;
INFLATION RATE = .13; FLOW RATIO OF A TO B ('ALPHA') = 1.0000
DAILY FLOW IN SYSTEM A = 100000 GALLONS; SYSTEM B = 100000 GALLONS

VALUES USED FOR DECISION PROCESS	TOTAL YR 1 TO 5	TOTAL YR 1 TO 10	TOTAL YR 1 TO 15	TOTAL YR 1 TO 20	TOTAL YR 1 TO 25	TOTAL YR 1 TO 30
TOT. OP. COSTS FOR ALTERN. A $	444000	1297000	2522000	4090000	5971000	8139000
TOT. OP. COSTS FOR ALTERN. B $	235000	686000	1334000	2164000	3159000	4306000
CURRENT SALVAGE VALUE FOR A $	256000	205000	153000	102000	51000	0
CURRENT SALVAGE VALUE FOR B $	811000	649000	487000	324000	162000	0
SLVG PER DISCNT CAP. (THETA-A)	.41431	.16478	.06144	.02036	.00506	< 10E-5
SLVG PER DISCNT CAP. (THETA-B)	1.31137	.52158	.19449	.06446	.01602	< 10E-5
TOT. FLOW (MGAL) FOR ALTERN A	175	350	525	700	875	1050
TOT. FLOW (MGAL) FOR ALTERN B	175	350	525	700	875	1050
RSUM FOR ALTERNATIVE A	2.67500	6.30247	9.15230	11.04570	12.20407	12.87883
RSUM FOR ALTERNATIVE B	1.41526	3.33444	4.84220	5.84394	6.45680	6.81379
*THE DISCRIMINANT IS	-.0083	1.1596	2.2779	3.0806	3.5930	3.8998
PVUC ($/MGAL PROCESSED): A $	2100	2700	2600	2500	2400	2300
PVUC ($/MGAL PROCESSED): B $	2200	2200	2100	2100	2000	2000
UAC ($MGAL PROC.) B $		2470 (1)				

STUDY CONDUCTED BY GEORGE A. GARRIGAN SEPTEMBER 9 1981.

* The "Discriminant" is the normalized difference between PVUC "A" and PVUC "B".

(1) Not computed in the original report.

ECONOMIC ANALYSIS, (FORMAT CONTINUED)

PROJECT TITLE: Carbon Adsorption, Iowa AAP (Thermal Regeneration)
PROJECT NO: 5794214, Task 3 (600,000 GPD) (10% Discounting) DATE: February 1981

7.	8. PROGRAM/PROJECT COSTS (MILLIONS $)					
Project Year (FY)	Non-Recurring Cost		c. Recurring/ Operating Cost	d. Annual Cost (Sum a,b,c)	e. Discount Factor (C.C.)	f. Discounted Annual Cost (d times e)
	a. R&D	b. Investment				
1		2.549			0.954	2.432
2		1.275			0.867	1.105
3			.362		0.788	.285
4			"		0.717	.259
5			"		0.652	.236
6			"		0.592	.214
7			"		0.538	.195
8			"		0.489	.177
9			"		0.445	.161
10			"		0.405	.147
11			"		0.368	.133
12			.362		0.334	.121
13		1.912	(S.V.)		~~0.304~~	(.581)
14					~~0.276~~	
15					~~0.251~~	
TOTALS						

9. Total Discounted Project Cost (Col. 8f. Total) $ 5.465 — $4.37/1000 gallons (UAC)
10. Discounted Terminal Value of Investments $ .581 — $2.33/1000 " (PVUC)
11. Net Total Discounted Project Costs (Line 9. less 10.) $ 4.884 / 5.328
12. Uniform Annual Cost (UAC) $ .917 per year.

TABLE 2 (b)

TABLE 3 - SUMMARY
PVUC ANALYSIS RECONCILIATION
PROCESS: CARBON ADSORPTION WITH THERMAL REGENERATION
LCWSL - VJCA
($ in Millions)
At Ten-Year Horizons
PROCEDURE: VJCA ORIGINAL vs. LCWSL ORIGINAL

		VJCA	LCWSL	DIFFERENCE For 100,000GPD	VJCA PVUC IMPACT
1.	Cost Data:				
	Capital Costs	.974	3.824	VJCA= +$.035	↑
	O&M Costs	.050	.362	VJCA=-$.011/yr.	↓
2.	Discount Rate	2%	10%	VJCA=Higher Inf.	↑
3.	Discount Comp	D.D.F.(2)	C.C.(2)	DCF=Lower Disc. Factors	↑
4.	Project Life	31 yrs.	22 yrs.		↑
	Economic Life	30 yrs.	20 yrs.		↑
5.	Plant Cap/GPD	100,000	600,000	LCWSL has econ. of scale	↑
6.	Salvage Value Year	10th	13th	S.V. Higher in 10	↓
7.	Capital Cost Yr. Spread	1 yr.	2 yrs.	LCWSL disc. K 2x.	↑
8.	Capital Cost Discount	None	2 yrs.	" " "	↑
9.	Lead Time to O&M	1 yr.	2 yrs.	LCWSL disc. O&M earlier.	↑
10.	Base Period (Costs)	Dec 1980	Avg. 1980	VJCA=higher costs	↑

				Ratio=VJCA/LCWSL
11.	PVUC/k gals.	$2.54(1)	$2.33	1.090
12.	UAC/k gals.(3)	$2.83(1)	$4.37	.648

Note:
(1) The cost estimates shown in lines 11 and 12 under the VJCA column are slightly higher than those originally reported due to an adjustment in the computer program made by VJCA to refine the computation model.
(2) D.C.F = Discrete Cash Flow; C.C. = Continuous Compounding.
(3) When a higher discount rate (10%) is used as the base for computing discount factors, the UAC is much larger than the PVUC for the same technology. When the discount rate is smaller, the PVUC and the UAC tend to come closer together.

TABLE 3(a)

PRESENT VALUE UNIT COST ANALYSIS
COMPARING TREATMENT A (CARBON ADSORPTION (NO REGENERATION))
WITH TREATMENT B (CARBON ADSORPTION (THERMAL REGENERATION)).
SYSTEM LIFESPAN TO BE 30 YEARS WITH 350 OP. DAYS PER YEAR.
ANALYSES ARE OVER FIVE YEAR SPANS (OR 'HORIZONS').

TOTAL CAPITAL COSTS FOR ALTERNATIVE A = $ 308000 AND FOR ALTERNATIVE B = $ 974000;
RATIO OF CAPITAL COSTS OF B TO CAPITAL COSTS OF A = 3.16; DISCOUNT RATE = .02;
FLOW RATIO OF A TO B ('ALPHA') = 1.0000
DAILY FLOW IN SYSTEM A = 100 000 GALLONS: SYSTEM B = 100 000 GALLONS.

PVUC RECONCILIATION

VALUES USED FOR DECISION PROCESS	TOTAL YR 1 TO 5	TOTAL YR 1 TO 10	TOTAL YR 1 TO 15	TOTAL YR 1 TO 20	TOTAL YR 1 TO 25	TOTAL YR 1 TO 30
TOT. OP. COSTS FOR ALTERN. A $	443000	844000	1207000	1537000	1835000	2105000
TOT. OP. COSTS FOR ALTERN. B $	235000	449000	642000	817000	976000	1119000
DISCOUNT SALVAGE VALUE FOR A $	232000	168000	114000	69000	31000	0
DISCOUNT SALVAGE VALUE FOR B $	735000	532000	361000	218000	98000	0
SLVG PER DISCNT CAP. (THETA-A)	.68362	.44864	.27603	.15096	.06192	< 10E-5
SLVG PER DISCNT CAP. (THETA-B)	2.16184	1.41877	.87291	.47739	.19581	< 10E-5
TOT. FLOW (MGAL) FOR ALTERN A	175	350	525	700	875	1050
TOT. FLOW (MGAL) FOR ALTERN B	175	350	525	700	875	1050
RSUM FOR ALTERNATIVE A	4.37253	15.52548	32.81967	55.67617	83.57062	????????
RSUM FOR ALTERNATIVE B	2.32581	8.25823	17.45727	29.61498	44.45246	61.71707
THE DISCRIMINANT IS	1.3626	6.0750	13.7969	24.2252	37.0897	52.1486
PVUC ($/KGAL PROCESSED): A $	2.96	2.81	2.66	2.53	2.41	2.41
PVUC ($/KGAL PROCESSED): B $	2.71	2.54	2.38	2.24	2.11	2.11
UNIFORM ANNUAL COST (A) $	3.14	3.12	3.11	3.10	3.09	3.07
UNIFORM ANNUAL COST (B) $	2.87	2.83	2.78	2.74	2.70	2.67

STUDY CONDUCTED BY CHAS. V. CICCONE NOVEMBER 27 1982

ECONOMIC ANALYSIS (FORMAT T CONTINUED)

PROJECT TITLE: Carbon Adsorption, Iowa AAP (Thermal Regeneration)
PROJECT NO: 5794214, Task 3 (600,000 GPD) (10% Discounting) DATE: February 1981

7.	8. PROGRAM/PROJECT COSTS (MILLIONS $)					
Project Year (FY)	Non-Recurring Cost		c. Recurring/ Operating Cost	d. Annual Cost (Sum a,b,c)	e. Discount Factor (C.C.)	f. Discounted Annual Cost (d times e)
	a. R&D	b. Investment				
1		2.549			0.954	2.432
2		1.275			0.867	1.105
3			.362		0.788	.285
4			"		0.717	.259
5			"		0.652	.236
6			"		0.592	.214
7			"		0.538	.195
8			"		0.489	.177
9			"		0.445	.161
10			"		0.405	.147
11			"		0.368	.133
12			.362		0.334	.121
13		1.912	(S.V.)		~~0.304~~	(.581)
14					~~0.276~~	
15					~~0.251~~	
TOTALS						

9. Total Discounted Project Cost (Col. 8f. Total) $ 5.465 — $4.37/1000 gallons (UAC)
10. Discounted Terminal Value of Investments $ .581 — $2.33/1000 " (PVUC)
11. Net Total Discounted Project Costs (Line 9. less 10.) $ 4.884 / 5.328
12. Uniform Annual Cost (UAC) $ .917 per year.

TABLE 3(b)

TABLE 4

PVUC ANALYSIS RECONCILIATION
PROCESS: CARBON ADSORPTION WITH THERMAL REGENERATION
LCWSL - VJCA
($ in Millions)
At Ten-Year Horizons
PROCEDURE: VJCA DATA @ 10% - LCWSL ORIGINAL @ 10%

		VJCA	LCWSL	
1.	Cost Data:			
	Capital Costs	.974	3.824	
	O&M Costs	.050	.362	
2.	Discount Rate	10%	10%	
3.	Discount Comp	D.D.F.	C.C.	
4.	Project Life	31 yrs.	22 yrs.	
	Economic Life	30 yrs.	20 yrs.	
5.	Plant Cap/GPD	100,000	600,000	
6.	Salvage Value Year	10th	13th	
7.	Capital Cost Yr.Spread	1 yr.	2 yrs.	
8.	Capital Cost Discount	None	2 yrs.	
9.	Lead Time to O&M	1 yr.	2 yrs.	
10.	Base Period (Costs)	Dec 1980	Avg. 1980	
11.	PVUC/k gals.	$2.94	$2.33	Ratio 1.26
12.	UAC/k gals.	$4.79	$4.37	1.10

TABLE 4(a)

PRESENT VALUE UNIT COST ANALYSIS
COMPARING TREATMENT A (CARBON ADSORPTION (THERMAL REGEN. -VJCA DATA.)
WITH TREATMENT B (CARBON ADSORPTION (THERMAL REGEN.)-VJCA DATA).
SYSTEM LIFESPAN TO BE 30 YEARS WITH 350 OP. DAYS PER YEAR.
ANALYSES ARE OVER FIVE YEAR SPANS (OR 'HORIZONS').

TOTAL CAPITAL COSTS FOR ALTERNATIVE A = $ 974000 AND FOR ALTERNATIVE B = $ 974000;
RATIO OF CAPITAL COSTS OF B TO CAPITAL COSTS OF A = 1.00; DISCOUNT RATE = .10;
FLOW RATIO OF A TO B ('ALPHA') = 1.0000
DAILY FLOW IN SYSTEM A = 100 000 GALLONS: SYSTEM B = 100 000 GALLONS.

PVUC RECONCILIATION - VJCA DATA (CORRECTED) @
10% DISCOUNT RATE.

VALUES USED FOR DECISION PROCESS	TOTAL YR 1 TO 5	TOTAL YR 1 TO 10	TOTAL YR 1 TO 15	TOTAL YR 1 TO 20	TOTAL YR 1 TO 25	TOTAL YR 1 TO 30
TOT. OP. COSTS FOR ALTERN. A $	189000	307000	380000	425000	453000	471000
TOT. OP. COSTS FOR ALTERN. B $	189000	307000	380000	425000	453000	471000
DISCOUNT SALVAGE VALUE FOR A $	503000	250000	116000	48000	14000	0
DISCOUNT SALVAGE VALUE FOR B $	503000	250000	116000	48000	14000	0
SLVG PER DISCNT CAP. (THETA-A)	.32128	.09909	.02865	.00736	.00141	< 10E-5
SLVG PER DISCNT CAP. (THETA-B)	.32128	.09909	.02865	.00736	.00141	< 10E-5
TOT. FLOW (MGAL) FOR ALTERN A	175	350	525	700	875	1050
TOT. FLOW (MGAL) FOR ALTERN B	175	350	525	700	875	1050
RSUM FOR ALTERNATIVE A	0.62074	1.97917	3.79564	5.89652	8.17400	10.56112
RSUM FOR ALTERNATIVE B	0.62074	1.97917	3.79564	5.89652	8.17400	10.56112
THE DISCRIMINANT IS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PVUC ($/KGAL PROCESSED): A $	3.76	2.94	2.35	1.93	1.61	1.61
PVUC ($/KGAL PROCESSED): B $	3.76	2.94	2.35	1.93	1.61	1.61
UNIFORM ANNUAL COST (A) $	4.97	4.79	4.64	4.53	4.44	4.38
UNIFORM ANNUAL COST (B) $	4.97	4.79	4.64	4.53	4.44	4.38

STUDY CONDUCTED BY C.V. CICCONE NOVEMBER 29 1982

ECONOMIC ANALYSIS (FORMAT CONTINUED)

PROJECT TITLE: Carbon Adsorption, Iowa AAP (Thermal Regeneration)
PROJECT NO: 5794214, Task 3 (600,000 GPD) (10% Discounting) DATE: February 1981

7. Project Year (FY)	8. PROGRAM/PROJECT COSTS (MILLIONS $)					
	Non-Recurring Cost		c. Recurring/ Operating Cost	d. Annual Cost (Sum a,b,c)	e. Discount Factor (C.C.)	f. Discounted Annual Cost (d times e)
	a. R&D	b. Investment				
1		2.549			0.954	2.432
2		1.275			0.867	1.105
3			.362		0.788	.285
4			"		0.717	.259
5			"		0.652	.236
6			"		0.592	.214
7			"		0.538	.195
8			"		0.489	.177
9			"		0.445	.161
10			"		0.405	.147
11			"		0.368	.133
12			.362		0.334	.121
13		1.912	(S.V.)		~~0.304~~	(.581)
14					~~0.276~~	
15					~~0.251~~	
TOTALS						

9. Total Discounted Project Cost (Col. 8f. Total). $ 5.465 — $4.37/1000 gallons (UAC)
10. Discounted Terminal Value of Investments $ .581 — $2.33/1000 " (PVUC)
11. Net Total Discounted Project Costs (Line 9. less 10.) $ 4.884 / 5.328
12. Uniform Annual Cost (UAC) $ .917 per year.

TABLE 4(b)

TABLE 5 - SUMMARY

PVUC ANALYSIS RECONCILIATION
PROCESS: CARBON ADSORPTION (THERMAL REGENERATION)
LCWSL - VJCA
($ in Millions)
At Ten-Year Horizons
PROCEDURE: VJCA DATA - LCWSL DATA IN LCWSL FORMAT (at 2%)

		VJCA	LCWSL	REMARKS
1.	Cost Data:	.649	2.549	No adjustments.
	Capital Costs	.325	1.275	No adjustments.
	O&M Costs	.050	.362	No adjustments.
2.	Discount Rate	2%	2%	Same discount rate.
3.	Discount Comp	C.C.	C.C.	Same computations.
4.	Project Life	30 yrs.	30 yrs.	Same.
	Economic Life	28 yrs.	28 yrs.	Same.
5.	Plant Cap/GPD	100,000	600,000	Economies of Scale for LCWSL(1)
6.	Salvage Value Year	12	12	Same.
7.	Capital Cost Yr. Spread	2 yrs.	2 yrs.	Same.
8.	Capital Cost Discount	2 yrs.	2 yrs.	Same.
9.	Lead Time to O&M	2 yrs.	2 yrs.	Same.
10.	Base Period (Costs)	Dec 1980	Aver. 1980	Higher orig. cost data for VJCA(1)
11.	PVUC/k gals.	$2.49	$2.33(2)	Ratio=VJCA/LCWSL 1.07
12.	UAC/k gals.	$2.83	$2.64	1.07

Note:

(1) Both economies of scale for LCWSL's operating at 600,000 GPD and the slightly lower original cost data for using the average 1980 result in decreases in PVUC for LCWSL.

(2) The PVUC for LCWSL's cost at 2% discounting is the same as the PVUC in its original 10% discounting computations. However, the original 10% calculations were based on a 20-year project life while the above calculations are based on a 30-year project life. Had the original LCWSL 10% calculations been based on a 30-year project life, its PVUC would have been 10 cents lower, or $2.23 at 10% compared to the above $2.33 at 2%.

PRESENT VALUE/UNIFORM ANNUAL COST ANALYSIS USING DOD FORMAT

Cost Data By: VJCA

1. Cost Data: Unadjusted
2. Discount Rate: 2%
3. Discount Comp: C.C.
4. Proj./Econ: Life 32 Yrs./30 Yrs.
5. Plant Cap. /GPD 100 k
   " " M/GPY .035 k
6. Salvage Value Yr. 12
7. Cap. Cost Spread 2 Yrs.
8. Cap. Cost Disc: 2 yrs.
9. Lead Time O&M: 2 Yr(s)
10. Base Period Costs: 12/80

System Analyzed: CARBON ADSORPTION (THERMAL REGENERATION)

Proj. Year (FY)	Econ. Year (FY)	PROGRAM/PROJECT COSTS (MILLIONS $) Non-Recurring Cost a. R&D	b. Investment	c. Recurring/ Operating Costs	d. Annual Cost (Sum a,b,c)	e. Discount Factor	f. Discounted Annual Cost (d times e)
1			.649			.991	.643
2			.325			.973	.316
3	1			.050		.955	.048
4	2			.050		.938	.047
5	3			.050		.921	.046
6	4			.050		.904	.045
7	5			.050		.888	.044
8	6			.050		.871	.043
9	7			.050		.856	.043
10	8			.050		.840	.042
11	9			.050		.825	.041
12	10)			.050		(.810	.040
12	10)	S.V. =	.649			(.810	(-.526)
Totals			.974	.500			

9. Total Discounted Project Cost (Col. 8f. Total).....$ 1.398
10. Discounted Salvage Value of Investments..... - .526
11. Net Total Discounted Project Costs (Line 9 less 10).....$ .872
12. Line 11 / Tot.Flow/K = .872 / .350 = ... PVUC/k Gals $2.49
13. Line 11 / Tot. O&M Factors = .872 / 8.806 = U.A.C $ .099
14. Line 13 / 1 Yr's. Flow = .099 / .035 = ...UAC/K Gals $2.83

PRESENT VALUE/UNIFORM ANNUAL COST ANALYSIS USING DOD FORMAT

Cost Data By: LCWSL

1. Cost Data: Unadjusted
2. Discount Rate: 2%
3. Discount Comp: C.C.
4. Proj./Econ: Life 32 Yrs./30 Yrs.
5. Plant Cap. /GPD 600 k
   " " M/GPY 210 k
6. Salvage Value Yr. 12
7. Cap. Cost Spread 2 Yrs.
8. Cap. Cost Disc: 2 yrs.
9. Lead Time O&M: 2 Yr(s)
10. Base Period Costs: Aver. '80

System Analyzed: CARBON ADSORPTION (THERMAL REGENERATION)

Proj. Year (FY)	Econ. Year (FY)	PROGRAM/PROJECT COSTS (MILLIONS $) Non-Recurring Cost a. R&D	b. Investment	c. Recurring/ Operating Costs	d. Annual Cost (Sum a,b,c)	e. Discount Factor	f. Discounted Annual Cost (d times e)
1			2.549			.991	2.526
2			1.275			.973	1.241
3	1			.362		.955	.346
4	2			.362		.938	.340
5	3			.362		.921	.333
6	4			.362		.904	.327
7	5			.362		.888	.321
8	6			.362		.871	.315
9	7			.362		.856	.310
10	8			.362		.840	.304
11	9			.362		.825	.299
12	10)			.362		(.810	.293
12	10)	S.V. =	2.549			(.810	(-2.065)
Totals			3.824	3.620			

9. Total Discounted Project Cost (Col. 8f. Total)..... $ 6.955
10. Discounted Salvage Value of Investments..... -2.065
11. Net Total Discounted Project Costs (Line 9 less 10)..... $ 4.890
12. Line 11 / Tot.Flow/K = 4.890 / 2.10 = ... PVUC /k Gals $ 2.33
13. Line 11 / Tot. O&M Factors = 4.890 / 8.806 = U.A.C $ .555
14. Line 13 / 1 Yr's. Flow = .555 / .210 = ... UAC/K Gals $ 2.64

TABLE 6 - SUMMARY

PVUC ANALYSIS RECONCILIATION
PROCESS: CARBON ADSORPTION (THERMAL REGENERATION)
LCWSL - VJCA
($ in Millions)
At Ten-Year Horizons
PROCEDURE: VJCA DATA, LCWSL DATA, & LCWSL COSTS AT 100K GPD - VJCA METHOD

		VJCA	LCWSL	LCWSL COSTS ADJUSTED TO 100/k GPD**
1.	Cost Data:	Unchanged	Unchanged	@ 100,000 GPD
	Capital Costs	.974	3.824	.939
	O&M Costs	.050/yr.	.362/yr.	.060/yr.
2.	Discount Rate	2%	2%	2%
3.	Discount Comp	DCF	DCF	DCF
4.	Project Life	31 yrs.	31 yrs.	31 yrs.
	Economic Life	30 yrs.	30 yrs.	30 yrs.
5.	Plant Cap/GPD	100,000	600,000	100,000
6.	Salvage Value Year	10th	10th	10th
7.	Capital Cost Yr. Spread	1 yr.	1 yr.	1 yr.
8.	Capital Cost Discount	None	None	None
9.	Lead Time to O&M	1 yr.	1 yr.	1 yr.
10.	Base Period (Costs)	Dec 1980(1)	Avg. 1980(1)	Aver. 1980(1)
11.	PVUC/k gals.	$2.54	$2.37	Ratio 1.07	$2.75(2)	Ratio .92
12.	UAC/k gals.	$2.83	$2.64	1.07	$3.06(2)	.92

Note: **See attached sheet for computation of adjustments down to 100/k GPD.

(1) Item #10 (Base Period (Costs)) of December 1980 increases cost data slightly for VJCA thereby increasing PVUC slightly over LCWSL's PVUC.

(2) Reducing the LCWSL cost data to those applicable to 100,000 GPD flow rather than 600,000 GPD flow eliminates the economies of scale of the higher GPD flow design. This loss of cost advantage for LCWSL plus the higher O&M initial costs for the LCWSL 100,000 GPD design, causes the PVUC and the UAC for LCWSL to rise significantly over the 600,000 GPD figures as well as over the VJCA 100,000 GPD figures.

LCWSL COST ADJUSTMENTS FROM 600,000 GPD
TO 100,000 GPD

I. CAPITAL COSTS

A. LCWSL	600,000 GPD	100,000 GPD
System	$3,462,312	$577,052 (1/6th)
Regenerator	361,775	361,775 (Full)
Total Capital Cost	$3,824,087	$938,827
B. VJCA		
System (Including Regenerator)		$974,080

II. O&M COSTS/YEAR

A. LCWSL	$362,476	$60,413
B. VJCA		$46,600

TABLE 6(a)

PRESENT VALUE UNIT COST ANALYSIS
COMPARING TREATMENT A (CARBON ADSORPTION (THERMAL REGEN. -LCWSL DATA)
WITH TREATMENT B (DUMMY).
SYSTEM LIFESPAN TO BE 30 YEARS WITH 350 OP. DAYS PER YEAR.
ANALYSES ARE OVER FIVE YEAR SPANS (OR 'HORIZONS').

TOTAL CAPITAL COSTS FOR ALTERNATIVE A = $ 3824000 AND FOR ALTERNATIVE B = $ 5774;
RATIO OF CAPITAL COSTS OF B TO CAPITAL COSTS OF A = . ; DISCOUNT RATE = .02;
FLOW RATIO OF A TO B ('ALPHA') = 1.0000
DAILY FLOW IN SYSTEM A = 600 000 GALLONS: SYSTEM B = 600 000 GALLONS.

PVUC RECONCILIATION-LCWSL DATA FOR 600K/GPD

VALUES USED FOR DECISION PROCESS	TOTAL YR 1 TO 5	TOTAL YR 1 TO 10	TOTAL YR 1 TO 15	TOTAL YR 1 TO 20	TOTAL YR 1 TO 25	TOTAL YR 1 TO 30
TOT. OP. COSTS FOR ALTERN. A $	1706000	3251000	4651000	5919000	7067000	8107000
TOT. OP. COSTS FOR ALTERN. B $	65000	124000	177000	226000	270000	310000
DISCOUNT SALVAGE VALUE FOR A $	2886000	2091000	1420000	857000	388000	0
DISCOUNT SALVAGE VALUE FOR B $	4000	3000	2000	1000	0	0
SLVG PER DISCNT CAP. (THETA-A)	.68362	.44864	.27603	.15096	.06192	< 10E-5
SLVG PER DISCNT CAP. (THETA-B)	.00103	.00067	.00041	.00022	< 10E-5	< 10E-5
TOT. FLOW (MGAL) FOR ALTERN A	1050	2100	3150	4200	5250	6300
TOT. FLOW (MGAL) FOR ALTERN B	1050	2100	3150	4200	5250	6300
RSUM FOR ALTERNATIVE A	1.35627	4.81569	10.18000	17.26962	25.92192	35.98957
RSUM FOR ALTERNATIVE B	0. 5186	0.18417	0.38932	0.66045	0.99135	1.37638
THE DISCRIMINANT IS	1.6203	5.1820	10.5135	17.4569	25.8672	35.6116
PVUC ($/KGAL PROCESSED): A $	2.51	2.37	2.23	2.11	2.00	2.00
PVUC ($/KGAL PROCESSED): B $	.06	.06	.05	.05	.05	.05
UNIFORM ANNUAL COST (A) $	2.67	2.64	2.61	2.58	2.56	2.53
UNIFORM ANNUAL COST (B) $	0.06	0.06	0.06	0.06	0.06	0.06

STUDY CONDUCTED BY C.V. CICCONE NOVEMBER 29 1982

TABLE 6(b)

PRESENT VALUE UNIT COST ANALYSIS
COMPARING TREATMENT A (CARBON ADSORPTION (NO REGENERATION))
WITH TREATMENT B (CARBON ADSORPTION (THERMAL REGENERATION)).
SYSTEM LIFESPAN TO BE 30 YEARS WITH 350 OP. DAYS PER YEAR.
ANALYSES ARE OVER FIVE YEAR SPANS (OR 'HORIZONS').

TOTAL CAPITAL COSTS FOR ALTERNATIVE A = $ 308000 AND FOR ALTERNATIVE B = $ 974000;
RATIO OF CAPITAL COSTS OF B TO CAPITAL COSTS OF A = 3.16; DISCOUNT RATE = .02;
FLOW RATIO OF A TO B ('ALPHA') = 1.0000
DAILY FLOW IN SYSTEM A = 100 000 GALLONS: SYSTEM B = 100 000 GALLONS.

PVUC RECONCILIATION

VALUES USED FOR DECISION PROCESS	TOTAL YR 1 TO 5	TOTAL YR 1 TO 10	TOTAL YR 1 TO 15	TOTAL YR 1 TO 20	TOTAL YR 1 TO 25	TOTAL YR 1 TO 30
TOT. OP. COSTS FOR ALTERN. A $	443000	844000	1207000	1537000	1835000	2105000
TOT. OP. COSTS FOR ALTERN. B $	235000	449000	642000	817000	976000	1119000
DISCOUNT SALVAGE VALUE FOR A $	232000	168000	114000	69000	31000	0
DISCOUNT SALVAGE VALUE FOR B $	735000	532000	361000	218000	98000	0
SLVG PER DISCNT CAP. (THETA-A)	.68362	.44864	.27603	.15096	.06192	< 10E-5
SLVG PER DISCNT CAP. (THETA-B)	2.16184	1.41877	.87291	.47739	.19581	< 10E-5
TOT. FLOW (MGAL) FOR ALTERN A	175	350	525	700	875	1050
TOT. FLOW (MGAL) FOR ALTERN B	175	350	525	700	875	1050
RSUM FOR ALTERNATIVE A	4.37253	15.52548	32.81967	55.67617	83.57062	????????
RSUM FOR ALTERNATIVE B	2.32581	8.25823	17.45727	29.61498	44.45246	61.71707
THE DISCRIMINANT IS	1.3626	6.0750	13.7969	24.2252	37.0897	52.1486
PVUC ($/KGAL PROCESSED): A $	2.96	2.81	2.66	2.53	2.41	2.41
PVUC ($/KGAL PROCESSED): B $	2.71	2.54	2.38	2.24	2.11	2.11
UNIFORM ANNUAL COST (A) $	3.14	3.12	3.11	3.10	3.09	3.07
UNIFORM ANNUAL COST (B) $	2.87	2.83	2.78	2.74	2.70	2.67

STUDY CONDUCTED BY CHAS. V. CICCONE NOVEMBER 27 1982

TABLE 6(c)

PRESENT VALUE UNIT COST ANALYSIS
COMPARING TREATMENT A (CARBON ADSORPTION (THERMAL REGEN.) LCWSL DATA)
WITH TREATMENT B (DUMMY).
SYSTEM LIFESPAN TO BE 30 YEARS WITH 350 OP. DAYS PER YEAR.
ANALYSES ARE OVER FIVE YEAR SPANS (OR 'HORIZONS').

TOTAL CAPITAL COSTS FOR ALTERNATIVE A = $ 939000 AND FOR ALTERNATIVE B = $ 5774;
RATIO OF CAPITAL COSTS OF B TO CAPITAL COSTS OF A = . ; DISCOUNT RATE = .02;
FLOW RATIO OF A TO B ('ALPHA') = 1.0000
DAILY FLOW IN SYSTEM A = 100 000 GALLONS: SYSTEM B = 100 000 GALLONS.

PVUC RECONCILIATION - LCWSL DATA REDUCED FOR 100K/GPD.

VALUES USED FOR DECISION PROCESS	TOTAL YR 1 TO 5	TOTAL YR 1 TO 10	TOTAL YR 1 TO 15	TOTAL YR 1 TO 20	TOTAL YR 1 TO 25	TOTAL YR 1 TO 30
TOT. OP. COSTS FOR ALTERN. A $	282000	538000	770000	981000	1171000	1343000
TOT. OP. COSTS FOR ALTERN. B $	65000	124000	177000	226000	270000	310000
DISCOUNT SALVAGE VALUE FOR A $	708000	513000	348000	210000	95000	0
DISCOUNT SALVAGE VALUE FOR B $	4000	3000	2000	1000	0	0
SLVG PER DISCNT CAP. (THETA-A)	.68362	.44864	.27603	.15096	.06192	< 10E-5
SLVG PER DISCNT CAP. (THETA-B)	.00420	.00275	.00169	.00092	.00038	< 10E-5
TOT. FLOW (MGAL) FOR ALTERN A	175	350	525	700	875	1050
TOT. FLOW (MGAL) FOR ALTERN B	175	350	525	700	875	1050
RSUM FOR ALTERNATIVE A	0.91546	3.25052	6.87136	11.65676	17.49694	24.29246
RSUM FOR ALTERNATIVE B	0.21123	0.75002	1.58548	2.68966	4.03722	5.60521
THE DISCRIMINANT IS	1.0186	3.0484	6.0053	9.8109	14.3920	19.6811
PVUC ($/KGAL PROCESSED): A $	2.93	2.75	2.59	2.44	2.30	2.30
PVUC ($/KGAL PROCESSED): B $	.38	.36	.34	.32	.31	.31
UNIFORM ANNUAL COST (A) $	3.11	3.06	3.02	2.98	2.94	2.91
UNIFORM ANNUAL COST (B) $	0.40	0.40	0.40	0.40	0.40	0.40

STUDY CONDUCTED BY C.V.CICCONE NOVEMBER 29 1982

APPENDIX B

RECONCILIATION TABLES FOR CARBON ADSORPTION WITHOUT REGENERATION

TABLE NO. 8*, 8(a), 8(b)
TABLE NO. 9*, 9(a), 9(b)
TABLE NO. 10*, 10(a)
TABLE NO. 11*, 11(a), 11(b), 11(c)

* Summary tables showing the differences between VJCA and LCWSL costs, discount rates, assumptions and calculating procedures for the process shown. PVUCs and UACs arrived at in the related calculation tables under the stated conditions, and the VJCA/LCWSL cost ratios are shown in lines 11 and 12 of the Summary Tables.

TABLE 8

PVUC ANALYSIS RECONCILIATION

PROCESS: CARBON ADSORPTION WITHOUT REGENERATION

LCWSL - VJCA

($ in Millions)

At Ten-Year Horizons

PROCEDURE: VJCA ORIGINAL - LCWSL ORIGINAL

		VJCA @100K Gals.	LCWSL @600K Gals.
1.	Cost Data:		2.308
	Capital Costs	.308	1.154
	O&M Costs	.094	.568
2.	Discount Rate	2%	10%
3.	Discount Comp	D.C.F.	C.C.
4.	Project Life	31 yrs.	22 yrs.
	Economic Life	30 yrs.	20 yrs.
5.	Plant Cap/GPD	100,000	600,000
6.	Salvage Value Year	10th	13th
7.	Capital Cost Yr. Spread	1 yr.	2 yrs.
8.	Capital Cost Discount	None	2 yrs.
9.	Lead Time to O&M	1 yr.	2 yrs.
10.	Base Period (Costs)	Dec 1980	Avg. 1980

				Ratio
11.	PVUC/k gals.	$2.70	$2.72	.99
12.	UAC/k gals.	$3.04	$5.10	.60

TABLE 8(a)

COMPUTER OUTPUT 3.1.3.1a
PRESENT VALUE UNIT COST ANALYSIS
COMPARING TREATMENT A (CARBON: NO REGENERATION (0.652 LBS TNT/LB C))
WITH TREATMENT B (CARBON: THERMAL REGEN. (0.652 LBS TNT/LB C)).
SYSTEM LIFESPAN TO BE 30 YEARS WITH 350 OP. DAYS PER YEAR.
ANALYSES ARE OVER FIVE YEAR SPANS (OR 'HORIZONS').

TOTAL CAPITAL COSTS FOR ALTERNATIVE A = $ 307750 AND FOR ALTERNATIVE B = $ 974080;
RATIO OF CAPITAL COSTS OF B TO CAPITAL COSTS OF A = 3.16; INTEREST RATE = .15;
INFLATION RATE = .13; FLOW RATIO OF A TO B ('ALPHA') = 1.0000
DAILY FLOW IN SYSTEM A = 100000 GALLONS; SYSTEM B = 100000 GALLONS

VALUES USED FOR DECISION PROCESS		TOTAL YR 1 TO 5	TOTAL YR 1 TO 10	TOTAL YR 1 TO 15	TOTAL YR 1 TO 20	TOTAL YR 1 TO 25	TOTAL YR 1 TO 30
TOT. OP. COSTS FOR ALTERN. A	$	444000	1297000 ✓	2522000	4090000	5971000	8139000
TOT. OP. COSTS FOR ALTERN. B	$	235000	686000	1334000	2164000	3159000	4306000
CURRENT SALVAGE VALUE FOR A	$	256000	205000 ✓	153000	102000	51000	0
CURRENT SALVAGE VALUE FOR B	$	811000	649000	487000	324000	162000	0
SLVG PER DISCNT CAP. (THETA-A)		.41431	.16478 ✓	.06144	.02036	.00506	< 10E-5
SLVG PER DISCNT CAP. (THETA-B)		1.31137	.52158	.19449	.06446	.01602	< 10E-5
TOT. FLOW (MGAL) FOR ALTERN A		175	350 ✓	525	700	875	1050
TOT. FLOW (MGAL) FOR ALTERN B		175	350	525	700	875	1050
RSUM FOR ALTERNATIVE A		2.67500	6.30247 ✓	9.15230	11.04570	12.20407	12.87883
RSUM FOR ALTERNATIVE B		1.41526	3.33444	4.84220	5.84394	6.45680	6.81379
*THE DISCRIMINANT IS		-.0083	1.1596	2.2779	3.0806	3.5930	3.8998
PVUC ($/MGAL PROCESSED): A	$	2KXX	.27XX ✓	2600	2500	2400	2300
PVUC ($/MGAL PROCESSED): B	$	27XX	22XX	21XX	2100	2000	2000
UAC($/mgal):A	$		3040				

STUDY CONDUCTED BY GEORGE A. GARRIGAN SEPTEMBER 9 1981.

* The "Discriminant" is the normalized difference between PVUC "A" and PVUC "B".

PROJECT TITLE: Carbon Adsorption - Iowa AAP (100% Virgin Carbon)
PROJECT NO: 5794214, Task 3 DATE: February 1981

7. Project Year (FY)	8. PROGRAM/PROJECT COSTS: (MILLIONS $)					
	Non-Recurring Cost		c. Recurring/ Operating Cost	d. Annual Cost (Sum a,b,c)	e. Discount Factor @ 10%	f. Discounted Annual Cost (d times e)
	a. R&D	b. Investment				
1		2.308			0.954	2.202
2		1.154			0.867	1.001
3			0.568		0.788	0.448
4			"		0.717	0.407
5			"		0.652	0.370
6			"		0.592	0.336
7			"		0.538	0.306
8			"		0.489	0.278
9			"		0.445	0.253
10			"		0.405	0.230
11			"		0.368	0.209
12			0.968		0.334	0.190
13		1.730	(S.V.) (20 yr life)		0.304	(0.526)
14					0.276	
15					0.251	
TOTALS						

PVUC $2.72/1000 gallons

9. Total Discounted Project Cost (Col. 8f. Total) $ 6.23 UAC 5.10/1000 gallons
10. Discounted Terminal Value of Investments $ .526
11. Net Total Discounted Project Costs (Line 9. less 10.) $ 5.704
12. Uniform Annual Cost (UAC) $ 1.071 per year. 5.328

TABLE 8 (b)

TABLE 9 - SUMMARY

PVUC ANALYSIS RECONCILIATION

PROCESS: CARBON ADSORPTION WITHOUT REGENERATION

LCWSL - VJCA

($ in Millions)

At Ten-Year Horizons

PROCEDURE: VJCA ORIGINAL (CORRECTED) - LCWSL ORIGINAL

		VJCA	LCWSL	
1.	Cost Data:		2.308	VJCA is $.269 lower/ 100k gal
	Capital Costs	.308	1.154	LCWSL disc. 2 years.
	O&M Costs	.094	.568	Same @ 100k gals.
2.	Discount Rate	2%	10%	
3.	Discount Comp	D.C.F.	C.C.	
4.	Project Life	31 yrs.	20 yrs.	
	Economic Life	30 yrs.	22 yrs.	
5.	Plant Cap/GPD	100,000	600,000	
6.	Salvage Value Year	10th	13th	
7.	Capital Cost Yr. Spread	1 yr.	2 yrs.	
8.	Capital Cost Discount	None	2 yrs.	
9.	Lead Time to O&M	1 yr.	2 yrs.	
10.	Base Period (Costs)	Dec 1980	Aver. 1980	

				Ratio (VJCA/LCWSL)
11.	PVUC/k gals.	$2.81	$2.72	1.03
12.	UAC/k gals.	$3.12	$5.10	.61

TABLE 9(a)

PRESENT VALUE UNIT COST ANALYSIS
COMPARING TREATMENT A (CARBON ADSORPTION (NO REGENERATION))
WITH TREATMENT B (CARBON ADSORPTION (THERMAL REGENERATION)).
SYSTEM LIFESPAN TO BE 30 YEARS WITH 350 OP. DAYS PER YEAR.
ANALYSES ARE OVER FIVE YEAR SPANS (OR 'HORIZONS').

TOTAL CAPITAL COSTS FOR ALTERNATIVE A = $ 308000 AND FOR ALTERNATIVE B = $ 974000;
RATIO OF CAPITAL COSTS OF B TO CAPITAL COSTS OF A = 3.16; DISCOUNT RATE = .02;
FLOW RATIO OF A TO B ('ALPHA') = 1.0000
DAILY FLOW IN SYSTEM A = 100 000 GALLONS: SYSTEM B = 100 000 GALLONS.

PVUC RECONCILIATION

VALUES USED FOR DECISION PROCESS	TOTAL YR 1 TO 5	TOTAL YR 1 TO 10	TOTAL YR 1 TO 15	TOTAL YR 1 TO 20	TOTAL YR 1 TO 25	TOTAL YR 1 TO 30
TOT. OP. COSTS FOR ALTERN. A $	443000	844000	1207000	1537000	1835000	2105000
TOT. OP. COSTS FOR ALTERN. B $	235000	449000	642000	817000	976000	1119000
DISCOUNT SALVAGE VALUE FOR A $	232000	168000	114000	69000	31000	0
DISCOUNT SALVAGE VALUE FOR B $	735000	532000	361000	218000	98000	0
SLVG PER DISCNT CAP. (THETA-A)	.68362	.44864	.27603	.15096	.06192	< 10E-5
SLVG PER DISCNT CAP. (THETA-B)	2.16184	1.41877	.87291	.47739	.19581	< 10E-5
TOT. FLOW (MGAL) FOR ALTERN A	175	350	525	700	875	1050
TOT. FLOW (MGAL) FOR ALTERN B	175	350	525	700	875	1050
RSUM FOR ALTERNATIVE A	4.37253	15.52548	32.81967	55.67617	83.57062	????????
RSUM FOR ALTERNATIVE B	2.32581	8.25823	17.45727	29.61498	44.45246	61.71707
THE DISCRIMINANT IS	1.3626	6.0750	13.7969	24.2252	37.0897	52.1486
PVUC ($/KGAL PROCESSED): A $	2.96	2.81	2.66	2.53	2.41	2.41
PVUC ($/KGAL PROCESSED): B $	2.71	2.54	2.38	2.24	2.11	2.11
UNIFORM ANNUAL COST (A) $	3.14	3.12	3.11	3.10	3.09	3.07
UNIFORM ANNUAL COST (B) $	2.87	2.83	2.78	2.74	2.70	2.67

STUDY CONDUCTED BY CHAS. V. CICCONE NOVEMBER 27 1982

PROJECT TITLE: Carbon Adsorption - Iowa AAP (100% Virgin Carbon)
PROJECT NO: 5794214, Task 3 DATE: February 1981

7: Project Year (FY)	8. PROGRAM/PROJECT COSTS: (MILLIONS $)					
	Non-Recurring Cost		c. Recurring/ Operating Cost	d. Annual Cost (Sum a,b,c)	e. Discount Factor @ 10%	f. Discounted Annual Cost (d times e)
	a. R&D	b. Investment				
1		2.308			0.954	2.202
2		1.154			0.867	1.001
3			0.568		0.788	0.448
4			"		0.717	0.407
5			"		0.652	0.370
6			"		0.592	0.336
7			"		0.538	0.306
8			"		0.489	0.278
9			"		0.445	0.253
10			"		0.405	0.230
11			"		0.368	0.209
12			0.568		0.334	0.190
13		1.730	(S.V.) (20 yr life)		0.304	(0.526)
14					0.276	
15					0.251	
TOTALS						

PVUC $2.72/1000 gallons
UAC 5.10/1000 gallons

9. Total Discounted Project Cost (Col. 8f. Total) $ 6.23
10. Discounted Terminal Value of Investments $ .526
11. Net Total Discounted Project Costs (Line 9. less 10.) $ 5.704
12. Uniform Annual Cost (UAC) $ 1.071 per year. 5.328

TABLE 9(b)

TABLE 10

PVUC ANALYSIS RECONCILIATION

PROCESS: CARBON ADSORPTION WITHOUT REGENERATION

LCWSL - VJCA

($ in Millions)

At Ten-Year Horizons

PROCEDURE: VJCA DATA - LCWSL DATA @ 100K/GPD, BOTH @ 10% (VJCA METHOD)

		VJCA	LCWSL
1.	Cost Data:		
	Capital Costs	.308	3.462
	O&M Costs	.094	.568
2.	Discount Rate	10%	10%
3.	Discount Comp	D.C.F.	D.C.F.
4.	Project Life	31 yrs.	31 yrs.
	Economic Life	30 yrs.	30 yrs.
5.	Plant Cap/GPD	100,000	100,000
6.	Salvage Value Year	10th	10th
7.	Capital Cost Yr. Spread	1 yr.	1 yr.
8.	Capital Cost Discount	None	None
9.	Lead Time to O&M	1 yr.	1 yr.
10.	Base Period (Costs)	Dec 1980	Avg. 1980

				Ratio
11.	PVUC/k gals.	$2.30	$2.87	.80
12.	UAC/k gals.	$3.74	$4.67	.80

TABLE 10(a)

PRESENT VALUE UNIT COST ANALYSIS
COMPARING TREATMENT A (CARBON ADSORPTION (NO REGEN. -VJCA DATA.)
WITH TREATMENT B (CARBON ADSORPTION (NO REGEN. -LCWSL DATA @100).
SYSTEM LIFESPAN TO BE 30 YEARS WITH 350 OP. DAYS PER YEAR.
ANALYSES ARE OVER FIVE YEAR SPANS (OR 'HORIZONS').

TOTAL CAPITAL COSTS FOR ALTERNATIVE A = $ 308000 AND FOR ALTERNATIVE B = $ 577000;
RATIO OF CAPITAL COSTS OF B TO CAPITAL COSTS OF A = 1.87; DISCOUNT RATE = .10;
FLOW RATIO OF A TO B ('ALPHA') = 1.0000
DAILY FLOW IN SYSTEM A = 100 000 GALLONS: SYSTEM B = 100 000 GALLONS.

PVUC RECONCILIATION - VJCA DATA @ 10% DISCOUNT
LCWSL DATA REDUCED TO 100K/GPD
LCWSL DATA AT 10% DISCOUNT
BOTH AT D.C.F. COMPUTATIONS.

VALUES USED FOR DECISION PROCESS	TOTAL YR 1 TO 5	TOTAL YR 1 TO 10	TOTAL YR 1 TO 15	TOTAL YR 1 TO 20	TOTAL YR 1 TO 25	TOTAL YR 1 TO 30
TOT. OP. COSTS FOR ALTERN. A $	356000	577000	714000	800000	853000	886000
TOT. OP. COSTS FOR ALTERN. B $	356000	577000	714000	800000	853000	886000
DISCOUNT SALVAGE VALUE FOR A $	159000	79000	36000	15000	4000	0
DISCOUNT SALVAGE VALUE FOR B $	298000	148000	69000	28000	8000	0
SLVG PER DISCNT CAP. (THETA-A)	.32128	.09909	.02865	.00736	.00141	< 10E-5
SLVG PER DISCNT CAP. (THETA-B)	.60188	.18564	.05368	.01379	.00265	< 10E-5
TOT. FLOW (MGAL) FOR ALTERN A	175	350	525	700	875	1050
TOT. FLOW (MGAL) FOR ALTERN B	175	350	525	700	875	1050
RSUM FOR ALTERNATIVE A	3.69045	11.76657	22.56585	35.05599	48.59603	62.78797
RSUM FOR ALTERNATIVE B	3.69045	11.76657	22.56585	35.05599	48.59603	62.78797
THE DISCRIMINANT IS	-.5927	-.7868	-.8483	-.8669	-.8721	-.8733
PVUC ($/KGAL PROCESSED): A $	2.88	2.30	1.87	1.56	1.32	1.32
PVUC ($/KGAL PROCESSED): B $	3.62	2.87	2.32	1.92	1.62	1.62
UNIFORM ANNUAL COST (A) $	3.80	3.74	3.70	3.66	3.64	3.61
UNIFORM ANNUAL COST (B) $	4.78	4.67	4.59	4.52	4.47	4.43

STUDY CONDUCTED BY C.V. CICCONE NOVEMBER 29 1982

TABLE 11 - SUMMARY

PVUC ANALYSIS RECONCILIATION
PROCESS: CARBON ADSORPTION WITHOUT REGENERATION
LCWSL - VJCA
($ in Millions)
At Ten-Year Horizons
PROCEDURE: VJCA ORIG. (CORRECTED) - LCWSL @600k GPD & @100k GPD - VJCA METHOD

		VJCA (@100k GPD)	LCWSL (@600k GPD)		LCWSL (@100k GPD)	
1.	Cost Data:					
	Capital Costs	.308	3.462		.577(1)	
	O&M Costs	.094	.568		.094	
2.	Discount Rate	2%	2%		2%	
3.	Discount Comp	DCF	DCF		DCF	
4.	Project Life	31 yrs.	31 yrs.		31 yrs.	
	Economic Life	30 yrs.	30 yrs.		30 yrs.	
5.	Plant Cap/GPD	100,000	600,000		100,000	
6.	Salvage Value Year	10th	10th		10th	
7.	Capital Cost Yr. Spread	1 yr.	1 yr.		1 yr.	
8.	Capital Cost Discount	None	None		None	
9.	Lead Time to O&M	1 yr.	1 yr.		1 yr.	
10.	Base Period (Costs)	Dec 1980	Avg. 1980		Aver. 1980	
11.	PVUC/k gals.	$2.81	$3.17	Ratio .88	$3.15(3)	Ratio .89
12.	UAC/k gals.	$3.12	$3.53	.88	$3.51(3)	.89

Note:
(1) Capital costs for LCWSL are $.269/100,000 gals. more than the VJCA capital costs for its 100,000 GPD system.
(2) Average 1980 base period for LCWSL results in slightly lower PVUC costs for its calculations.
(3) The difference between VJCA's $2.81 PVUC and LCWSL's $3.16 PVUC at equivalent 100,000 GPD flows is mostly accounted for by the $.269 difference in capital costs for the same daily flow design in LCWSL's computations.

TABLE 11(a)

PRESENT VALUE UNIT COST ANALYSIS
COMPARING TREATMENT A (CARBON ADSORPTION (NO REGENERATION))
WITH TREATMENT B (CARBON ADSORPTION (THERMAL REGENERATION)).
SYSTEM LIFESPAN TO BE 30 YEARS WITH 350 OP. DAYS PER YEAR.
ANALYSES ARE OVER FIVE YEAR SPANS (OR 'HORIZONS').

TOTAL CAPITAL COSTS FOR ALTERNATIVE A = $ 308000 AND FOR ALTERNATIVE B = $ 974000;
RATIO OF CAPITAL COSTS OF B TO CAPITAL COSTS OF A = 3.16; DISCOUNT RATE = .02;
FLOW RATIO OF A TO B ('ALPHA') = 1.0000
DAILY FLOW IN SYSTEM A = 100 000 GALLONS: SYSTEM B = 100 000 GALLONS.

PVUC RECONCILIATION

VALUES USED FOR DECISION PROCESS	TOTAL YR 1 TO 5	TOTAL YR 1 TO 10	TOTAL YR 1 TO 15	TOTAL YR 1 TO 20	TOTAL YR 1 TO 25	TOTAL YR 1 TO 30
TOT. OP. COSTS FOR ALTERN. A $	443000	844000	1207000	1537000	1835000	2105000
TOT. OP. COSTS FOR ALTERN. B $	235000	449000	642000	817000	976000	1119000
DISCOUNT SALVAGE VALUE FOR A $	232000	168000	114000	69000	31000	0
DISCOUNT SALVAGE VALUE FOR B $	735000	532000	361000	218000	98000	0
SLVG PER DISCNT CAP. (THETA-A)	.68362	.44864	.27603	.15096	.06192	< 10E-5
SLVG PER DISCNT CAP. (THETA-B)	2.16184	1.41877	.87291	.47739	.19581	< 10E-5
TOT. FLOW (MGAL) FOR ALTERN A	175	350	525	700	875	1050
TOT. FLOW (MGAL) FOR ALTERN B	175	350	525	700	875	1050
RSUM FOR ALTERNATIVE A	4.37253	15.52548	32.81967	55.67617	83.57062	????????
RSUM FOR ALTERNATIVE B	2.32581	8.25823	17.45727	29.61498	44.45246	61.71707
THE DISCRIMINANT IS	1.3626	6.0750	13.7969	24.2252	37.0897	52.1486
PVUC ($/KGAL PROCESSED): A $	2.96	2.81	2.66	2.53	2.41	2.41
PVUC ($/KGAL PROCESSED): B $	2.71	2.54	2.38	2.24	2.11	2.11
UNIFORM ANNUAL COST (A) $	3.14	3.12	3.11	3.10	3.09	3.07
UNIFORM ANNUAL COST (B) $	2.87	2.83	2.78	2.74	2.70	2.67

STUDY CONDUCTED BY CHAS. V. CICCONE NOVEMBER 27 1982

TABLE 11(b)

PRESENT VALUE UNIT COST ANALYSIS
COMPARING TREATMENT A (CARBON ADSORPTION (NO REGEN. -LCWSL DATA @600)
WITH TREATMENT B (DUMMY).
SYSTEM LIFESPAN TO BE 30 YEARS WITH 350 OP. DAYS PER YEAR.
ANALYSES ARE OVER FIVE YEAR SPANS (OR 'HORIZONS').

TOTAL CAPITAL COSTS FOR ALTERNATIVE A = $ 3462000 AND FOR ALTERNATIVE B = $ 5774;
RATIO OF CAPITAL COSTS OF B TO CAPITAL COSTS OF A = . ; DISCOUNT RATE = .02;
FLOW RATIO OF A TO B ('ALPHA') = 1.0000
DAILY FLOW IN SYSTEM A = 600 000 GALLONS; SYSTEM B = 600 000 GALLONS.

PVUC RECONCILIATION

VALUES USED FOR DECISION PROCESS	TOTAL YR 1 TO 5	TOTAL YR 1 TO 10	TOTAL YR 1 TO 15	TOTAL YR 1 TO 20	TOTAL YR 1 TO 25	TOTAL YR 1 TO 30
TOT. OP. COSTS FOR ALTERN. A $	2677000	5102000	7298000	9287000	11089000	12721000
TOT. OP. COSTS FOR ALTERN. B $	65000	124000	177000	226000	270000	310000
DISCOUNT SALVAGE VALUE FOR A $	2613000	1893000	1286000	776000	351000	0
DISCOUNT SALVAGE VALUE FOR B $	4000	3000	2000	1000	0	0
SLVG PER DISCNT CAP. (THETA-A)	.68362	.44864	.27603	.15096	.06192	< 10E-5
SLVG PER DISCNT CAP. (THETA-B)	.00114	.00074	.00046	.00025	.00010	< 10E-5
TOT. FLOW (MGAL) FOR ALTERN A	1050	2100	3150	4200	5250	6300
TOT. FLOW (MGAL) FOR ALTERN B	1050	2100	3150	4200	5250	6300
RSUM FOR ALTERNATIVE A	2.35059	8.34621	17.64324	29.93046	44.92600	62.37453
RSUM FOR ALTERNATIVE B	0. 5729	0.20342	0.43003	0.72951	1.09501	1.52030
THE DISCRIMINANT IS	2.6091	8.6932	17.9359	30.0485	44.7674	61.8525
PVUC ($/KGAL PROCESSED): A $	3.35	3.17	3.00	2.85	2.70	2.70
PVUC ($/KGAL PROCESSED): B $	.06	.06	.05	.05	.05	.05
UNIFORM ANNUAL COST (A) $	3.56	3.53	3.51	3.48	3.46	3.44
UNIFORM ANNUAL COST (B) $	0.01	0.01	0.02	0.02	0.03	0.03

STUDY CONDUCTED BY CHAS. V. CICCONE NOVEMBER 27 1982

TABLE 11(c)

PRESENT VALUE UNIT COST ANALYSIS
COMPARING TREATMENT A (CARBON ADSORPTION (NO REGEN.-LCWSL DATA REDUC)
WITH TREATMENT B ((DUMMY)).
SYSTEM LIFESPAN TO BE 30 YEARS WITH 350 OP. DAYS PER YEAR.
ANALYSES ARE OVER FIVE YEAR SPANS (OR 'HORIZONS').

TOTAL CAPITAL COSTS FOR ALTERNATIVE A = $ 577000 AND FOR ALTERNATIVE B = $ 5774;
RATIO OF CAPITAL COSTS OF B TO CAPITAL COSTS OF A = .1; DISCOUNT RATE = .02;
FLOW RATIO OF A TO B ('ALPHA') = 1.0000
DAILY FLOW IN SYSTEM A = 100 000 GALLONS: SYSTEM B = 100 000 GALLONS.

PVUC RECONCILIATION (LCWSL DATA REDUCED TO 100K/GPD)

VALUES USED FOR DECISION PROCESS	TOTAL YR 1 TO 5	TOTAL YR 1 TO 10	TOTAL YR 1 TO 15	TOTAL YR 1 TO 20	TOTAL YR 1 TO 25	TOTAL YR 1 TO 30
TOT. OP. COSTS FOR ALTERN. A $	443000	844000	1207000	1537000	1835000	2105000
TOT. OP. COSTS FOR ALTERN. B $	65000	124000	177000	226000	270000	310000
DISCOUNT SALVAGE VALUE FOR A $	435000	315000	214000	129000	58000	0
DISCOUNT SALVAGE VALUE FOR B $	4000	3000	2000	1000	0	0
SLVG PER DISCNT CAP. (THETA-A)	.68362	.44864	.27603	.15096	.06192	< 10E-5
SLVG PER DISCNT CAP. (THETA-B)	.00684	.00448	.00276	.00151	.00061	< 10E-5
TOT. FLOW (MGAL) FOR ALTERN A	175	350	525	700	875	1050
TOT. FLOW (MGAL) FOR ALTERN B	175	350	525	700	875	1050
RSUM FOR ALTERNATIVE A	2.33403	8.28743	17.51899	29.71968	44.60962	61.93527
RSUM FOR ALTERNATIVE B	0.34375	1.22057	2.58019	4.37711	6.57010	9.12183
THE DISCRIMINANT IS	2.3034	7.6126	15.6555	26.1831	38.9682	53.8034
PVUC ($/KGAL PROCESSED): A $	3.34	3.15	2.99	2.83	2.68	2.68
PVUC ($/KGAL PROCESSED): B $	.38	.36	.34	.32	.31	.31
UNIFORM ANNUAL COST (A) $	3.54	3.51	3.49	3.46	3.44	3.42
UNIFORM ANNUAL COST (B) $	0.40	0.40	0.40	0.40	0.40	0.40

STUDY CONDUCTED BY C.V.CICCONE NOVEMBER 29 1982

APPENDIX C

RECONCILIATION TABLES FOR ULTRAVIOLET OZONOLYSIS

TABLE NO. 13*, 13(a), 13(b)
TABLE NO. 14*, 14(a), 14(b)
TABLE NO. 15*, 15(a), 15(b)
TABLE NO. 16*, 16(a), 16(b)
TABLE NO. 17*, 17(a)

* Summary tables showing the differences between VJCA and LCWSL costs, discount rates, assumptions and calculating procedures for the process shown. PVUCs and UACs arrived at in the related calculation tables under the stated conditions, and the VJCA/LCWSL cost ratios are shown in lines 11 and 12 of the Summary Tables.

TABLE 13

PVUC ANALYSIS RECONCILIATION

PROCESS: ULTRAVIOLET OZONOLYSIS

LCWSL - VJCA

($ in Millions)

At Ten-Year Horizons

PROCEDURE: VJCA ORIGINAL - LCWSL ORIGINAL

		VJCA	LCWSL	DIFFERENCE	VJCA PVUC IMPACT
1.	Cost Data:		.733		
	Capital Costs	.623	.367	$.432 less for VJCA	
	O&M Costs	.328	.230	$.098/yr. more for VJCA	
2.	Discount Rate	2%	10%	VJCA assumes inflation.	
3.	Discount Comp	D.C.F.	C.C.	VJC=onetime expend./ year.	
4.	Project Life	31 yrs.	17 yrs.		
	Economic Life	30 yrs.	15 yrs.		
5.	Plant Cap/GPD	100,000	100,000	Same.	
6.	Salvage Value Year	10th	13th		
7.	Capital Cost Yr. Spread	1 yr.	2 yrs.		
8.	Capital Cost Discount	None	2 yrs.		
9.	Lead Time to O&M	1 yr.	2 yrs.		
10.	Base Period (Costs)	Dec 1980	Aver. 1980	VJCA assumes cost data.	
11.	PVUC/k gals.	$9.00	$6.09(1)	Ratio 1.48	
12.	UAC/k gals.	$10.27(1)	$11.42	.90	

Note:

(1) Not originally calculated.

TABLE 13(a)

COMPUTER OUTPUT 3.1.3.4a
PRESENT VALUE UNIT COST ANALYSIS
COMPARING TREATMENT A (CARBON: THERMAL REGENERATION (0.652 LBS TNT/L)
WITH TREATMENT B (ULTRAVIOLET-OZONE).
SYSTEM LIFESPAN TO BE 30 YEARS WITH 350 OP. DAYS PER YEAR.
ANALYSES ARE OVER FIVE YEAR SPANS (OR 'HORIZONS').

TOTAL CAPITAL COSTS FOR ALTERNATIVE A = $ 974080 AND FOR ALTERNATIVE B = $ 623380;
RATIO OF CAPITAL COSTS OF B TO CAPITAL COSTS OF A = .63; INTEREST RATE = .15;
INFLATION RATE = .13; FLOW RATIO OF A TO B ('ALPHA') = 1.0000
DAILY FLOW IN SYSTEM A = 100000 GALLONS; SYSTEM B = 100000 GALLONS

VALUES USED FOR DECISION PROCESS	TOTAL YR 1 TO 5	TOTAL YR 1 TO 10	TOTAL YR 1 TO 15	TOTAL YR 1 TO 20	TOTAL YR 1 TO 25	TOTAL YR 1 TO 30
TOT. OP. COSTS FOR ALTERN. A $	235000	686000	1334000	2164000	3159000	4306000
TOT. OP. COSTS FOR ALTERN. B $	1547000	4512000	8776000	14228000	20771000	28311000
CURRENT SALVAGE VALUE FOR A $	811000	649000	487000	324000	162000	0
CURRENT SALVAGE VALUE FOR B $	519000	415000	311000	207000	103000	0
SLVG PER DISCNT CAP. (THETA-A)	.41431	.16478	.06144	.02036	.00506	< 10E-5
SLVG PER DISCNT CAP. (THETA-B)	.26514	.10546	.03932	.01303	.00324	< 10E-5
TOT. FLOW (MGAL) FOR ALTERN A	175	350	525	700	875	1050
TOT. FLOW (MGAL) FOR ALTERN B	175	350	525	700	875	1050
RSUM FOR ALTERNATIVE A	0.44713	1.05348	1.52984	1.84633	2.03995	2.15274
RSUM FOR ALTERNATIVE B	2.93979	6.92634	10.05828	12.13910	13.41214	14.15369
*THE DISCRIMINANT IS	-2.2817	-5.5721	-8.1905	-9.9400	-11.0139	-11.6409
PVUC ($/MGAL PROCESSED): A $	2200	2200	2100	2100	2000	2000
PVUC ($/MGAL PROCESSED) (B) $	9400	9000	8700	8300	8000	7700
UAC (B/MGAL) (B)		1027				

STUDY CONDUCTED BY VINCENT J CICCONE SEPTEMBER 23 1981

* The "Discriminant" is the normalized difference between PVUC "A" and PVUC "B".

PROJECT TITLE: UV/Ozonolysis Treatment of Pink Wastewater (1000 GPD Demonstration)

PROJECT NO: (Salvage Value based on 15-yr. Proj. Life) DATE: February 1981

7. Project Year (FY)	8. PROGRAM/PROJECT COSTS (MILLIONS-$)					
	Non-Recurring Cost		c. Recurring/ Operating Cost	d. Annual Cost (Sum a,b,c)	e. Discount Factor	f. Discounted Annual Cost (d times e)
	a. R&D	b. Investment				
1		.733			0.954	.699
2		.367			0.867	.318
3			.230		0.788	.181
4			.230		0.717	.165
5			.230		0.652	.150
6			.230		0.592	.136
7			.230		0.538	.124
8			.230		0.489	.112
9			.230		0.445	.102
10			.230		0.405	.093
11			.230		0.368	.085
12			.230		0.334	.077
13		.367 (SV) 1/			0.304	(.112)
14					0.276	
15					0.251	
TOTALS						

PVUC =$ 6.09/1000

9. Total Discounted Project Cost (Col. 8f. Total) $ 2.242 UAC =$11.42/1000
10. Discounted Terminal Value of Investments $ .112
11. Net Total Discounted Project Costs (Line 9. less 10.) $2.13
12. Uniform Annual Cost (UAC) $ .400 per year. 5.328

1/ According to this amount, it is assumed that a 15-year project life was the basis for the salvage value calculation (using the straight line method of depreciation).

TABLE 13(b)

TABLE 14

PVUC ANALYSIS RECONCILIATION

PROCESS: ULTRAVIOLET OZONOLYSIS

LCWSL - VJCA

($ in Millions)

At Ten-Year Horizons

PROCEDURE: VJCA ORIG> (CORRECTED) - LCWSL ORIGINAL

		VJCA	LCWSL	
1.	Cost Data:		.733	
	Capital Costs	.623	.367	
	O&M Costs	.328	.230	
2.	Discount Rate	2%	10%	
3.	Discount Comp	D.C.F.	C.C.	
4.	Project Life	31 yrs.	17 yrs.	
	Economic Life	30 yrs.	15 yrs.	
5.	Plant Cap/GPD	100,000	100,000	
6.	Salvage Value Year	10th	13th	
7.	Capital Cost Yr. Spread	1 yr.	2 yrs.	
8.	Capital Cost Discount	None	2 yrs.	
9.	Lead Time to O&M	1 yr.	2 yrs.	
10.	Base Period (Costs)	Dec 1980	Avg. 1980	
11.	PVUC/k gals.	$9.23	$6.09(1)	Ratio 1.51
12.	UAC/k gals.	$10.28	$11.42	.90

NOTE:

(1) PVUC amount not calculated by LCWSL in its original computations.

TABLE 14(a)

PRESENT VALUE UNIT COST ANALYSIS
COMPARING TREATMENT A (ULTRAVIOLET OZONOLYSIS- VJCA CORRECTED)
WITH TREATMENT B (ULTRAVIOLET OZONOLYSIS. [illegible]-VJCA FORMAT).
SYSTEM LIFESPAN TO BE 30 YEARS WITH 350 OP. DAYS PER YEAR.
ANALYSES ARE OVER FIVE YEAR SPANS (OR 'HORIZONS').

TOTAL CAPITAL COSTS FOR ALTERNATIVE A = $ 632000 AND FOR ALTERNATIVE B = $ 1100000;
RATIO OF CAPITAL COSTS OF B TO CAPITAL COSTS OF A = 1.74; DISCOUNT RATE = .02;
FLOW RATIO OF A TO B ('ALPHA') = 1.0000
DAILY FLOW IN SYSTEM A = 100 000 GALLONS: SYSTEM B = 100 000 GALLONS.

PVUC RECONCILIATION - VJCA (CORRECTED) WITH LCWSL IN VJCA METHOD.

VALUES USED FOR DECISION PROCESS	TOTAL YR 1 TO 5	TOTAL YR 1 TO 10	TOTAL YR 1 TO 15	TOTAL YR 1 TO 20	TOTAL YR 1 TO 25	TOTAL YR 1 TO 30
TOT. OP. COSTS FOR ALTERN. A $	1546000	2946000	4214000	5363000	6403000	7346000
TOT. OP. COSTS FOR ALTERN. B $	1084000	2065000	2955000	3760000	4490000	5151000
DISCOUNT SALVAGE VALUE FOR A $	477000	345000	234000	141000	64000	0
DISCOUNT SALVAGE VALUE FOR B $	830000	601000	408000	246000	111000	0
SLVG PER DISCNT CAP. (THETA-A)	.68362	.44864	.27603	.15096	.06192	< 10E-5
SLVG PER DISCNT CAP. (THETA-B)	1.18985	.78087	.48044	.26275	.10777	< 10E-5
TOT. FLOW (MGAL) FOR ALTERN A	175	350	525	700	875	1050
TOT. FLOW (MGAL) FOR ALTERN B	175	350	525	700	875	1050
RSUM FOR ALTERNATIVE A	7.43554	26.40127	55.81024	94.67799	????????	????????
RSUM FOR ALTERNATIVE B	5.21394	18.51308	39.13523	66.39005	99.65228	????????
THE DISCRIMINANT IS	1.9873	7.4799	16.1389	27.6592	41.7658	58.2110
PVUC ($/KGAL PROCESSED): A $	9.71	9.23	8.78	8.36	7.96	7.96
PVUC ($/KGAL PROCESSED): B $	7.73	7.32	6.94	6.59	6.26	6.26
UNIFORM ANNUAL COST (A) $	10.31	10.28	10.25	10.22	10.20	10.17
UNIFORM ANNUAL COST (B) $	8.20	8.15	8.10	8.06	8.01	7.97

STUDY CONDUCTED BY C.V. CICCONE NOVEMBER 29 1982

PROJECT TITLE: UV/Ozonolysis Treatment of Pink Wastewater (1000,000 gallons/day)
PROJECT NO: (Salvage Value based on 15-yr. Proj. Life) DATE: February 1981

7. Project Year (FY)	8. PROGRAM/PROJECT COSTS (MILLIONS-$)					
	Non-Recurring Cost		c. Recurring/ Operating Cost	d. Annual Cost (Sum a,b,c)	e. Discount Factor	f. Discounted Annual Cost (d times e)
	a. R&D	b. Investment				
1		.733			0.954	.699
2		.367			0.867	.318
3			.230		0.788	.181
4			.230		0.717	.165
5			.230		0.652	.150
6			.230		0.592	.136
7			.230		0.538	.124
8			.230		0.489	.112
9			.230		0.445	.102
10			.230		0.405	.093
11			.230		0.368	.085
12			.230		0.334	.077
13		.367 (S.V.) 1/			0.304	(.112)
14					0.276	
15					0.251	
TOTALS						

PVUC =$ 6.09/1000 gallons
UAC =$11.42/1000 gallons

9. Total Discounted Project Cost (Col. 8f. Total) $ 2.242
10. Discounted Terminal Value of Investments $ .112
11. Net Total Discounted Project Costs (Line 9. less 10.) $2.13
12. Uniform Annual Cost (UAC) $ .400 per year. 5.328

1/ According to this amount, it is assumed that a 15-year project life was the basis for the salvage value calculation (using the straight line method of depreciation).

Page ___ of ___

TABLE 14(b)

TABLE 15

PVUC ANALYSIS RECONCILIATION

PROCESS: ULTRAVIOLET OZONOLYSIS

LCWSL - VJCA

($ in Millions)

At Ten-Year Horizons

PROCEDURE: VJCA DATA @ LCWSL METHOD - LCWSL ORIG. DATA (15 Yr. Life)

		VJCA	LCWSL	
1.	Cost Data:	.415	.733	
	Capital Costs	.208	.367	
	O&M Costs	.328	.230	
2.	Discount Rate	10%	10%	
3.	Discount Comp	C.C.	C.C.	
4.	Project Life	17 yrs.	17 yrs.	
	Economic Life	15 yrs.	15 yrs.	
5.	Plant Cap/GPD	100,000	100,000	
6.	Salvage Value Year	13th	13th	
7.	Capital Cost Yr. Spread	2 yrs.	2 yrs.	
8.	Capital Cost Discount	2 yrs.	2 yrs.	
9.	Lead Time to O&M	2 yrs.	2 yrs.	
10.	Base Period (Costs)	Dec 1980	Avg. 1980	
11.	PVUC/k gals.	$6.46	$6.09	Ratio 1.06
12.	UAC/k gals.	$12.12	$11.42	1.06

PRESENT VALUE/UNIFORM ANNUAL COST ANALYSIS USING DOD FORMAT

Cost Data By: VJCA (LCWSL PROCEDURE) - 15-YR. PROJ. LIFE (Original)

1. Cost Data: Unadj { K= -$.432 / O&M=+$.098/yr.
2. Discount Rate: 10%
3. Discount Comp: C.C
4. Proj./Econ: Life 17 Yrs./ 15Yrs.
5. Plant Cap. /GPD 100 k / M/GPY .035 k
6. Salvage Value Yr. 13
7. Cap. Cost Spread 2 Yrs.
8. Cap. Cost Disc: 2 yrs.
9. Lead Time O&M: 2 Yr(s)
10. Base Period Costs: 12/'80.

System Analyzed: ULTRAVIOLET OZONOLYSIS (UV OZONE)

Proj. Year (FY)	Econ. Year (FY)	PROGRAM/PROJECT COSTS (MILLIONS $) Non-Recurring Cost a. R&D	b. Investment	c. Recurring/ Operating Costs	d. Annual Cost (Sum a,b,c)	e. Discount Factor	f. Discounted Annual Cost (d times e)
1			.415			.954	.396
2			.208			.867	.180
3	1			.328		.788	.258
4	2			.328		.717	.235
5	3			.328		.652	.214
6	4			.328		.592	.194
7	5			.328		.538	.176
8	6			.328		.489	.160
9	7			.328		.445	.146
10	8			.328		.405	.133
11	9			.328		.368	.121
12	10			.328		.334	.110
13	11	S.V. =	.208(based	on 15 yr. proj. life)		.304	(-.063)
Totals							

9. Total Discounted Project Cost (Col. 8f. Total)..... $ 2.323
10. Discounted Salvage Value of Investments..... - .063
11. Net Total Discounted Project Costs (Line 9 less 10)..... $ 2.260
12. Line 11 / Tot.Flow/K = 2.260 / .359 = ... PVUC/k Gals $6.46
13. Line 11 / Tot. O&M Factors = 2.260 / 5.328 = U.A.C $ .424
14. Line 13 / 1 Yr's. Flow = .424 / .035 = ...UAC/K Gals $12.12

PROJECT TITLE: UV/Ozonolysis Treatment of Pink Wastewaters (1000 gallons/day)

PROJECT NO: (Salvage Value based on 15-yr. Proj. Life) DATE: February 1981

7. Project Year (FY)	8. PROGRAM/PROJECT COSTS (MILLIONS-$)					
	Non-Recurring Cost		c. Recurring/ Operating Cost	d. Annual Cost (Sum a,b,c)	e. Discount Factor	f. Discounted Annual Cost (d times e)
	a. R&D	b. Investment				
1		.733			0.954	.699
2		.367			0.867	.318
3			.230		0.788	.181
4			.230		0.717	.165
5			.230		0.652	.150
6			.230		0.592	.136
7			.230		0.538	.124
8			.230		0.489	.112
9			.230		0.445	.102
10			.230		0.405	.093
11			.230		0.368	.085
12			.230		0.334	.077
13		.367 (S.V.) 1/			0.304	(.112)
14					0.276	
15					0.251	
TOTALS						

PVUC =$ 6.09/1000 gallons

9. Total Discounted Project Cost (Col. 8f. Total) $ 2.242 UAC =$11.42/1000 gallons
10. Discounted Terminal Value of Investments $ .112
11. Net Total Discounted Project Costs (Line 9. less 10.) $2.13
12. Uniform Annual Cost (UAC) $ .400 per year. 5,328

1/ According to this amount, it is assumed that a 15-year project life was the basis for the salvage value calculation (using the straight line method of depreciation).

TABLE 15(b)

TABLE 16

PVUC ANALYSIS RECONCILIATION

PROCESS: ULTRAVIOLET OZONOLYSIS

LCWSL - VJCA

($ in Millions)

At Ten-Year Horizons

PROCEDURE: VJCA ORIG. (CORRECTED) - LCWSL ORIGINAL (CORRECTED FOR S.V.)

		VJCA	LCWSL	
1.	Cost Data:		.733	
	Capital Costs	.623	.367	
	O&M Costs	.328	.230	
2.	Discount Rate	2%	10%	
3.	Discount Comp	D.C.F.	C.C.	
4.	Project Life	31 yrs.	32 yrs.	
	Economic Life	30 yrs.	30 yrs.	
5.	Plant Cap/GPD	100,000	100,000	
6.	Salvage Value Year	10th	11th	
7.	Capital Cost Yr. Spread	1 yr.	2 yrs.	
8.	Capital Cost Discount	None	2 yrs.	
9.	Lead Time to O&M	1 yr.	2 yrs.	
10.	Base Period (Costs)	Dec 1980	Avg. 1980	
11.	PVUC/k gals.	$9.23	$5.77	Ratio 1.60
12.	UAC/k gals.	$10.28	$10.83	.94

TABLE 16(a)

PRESENT VALUE UNIT COST ANALYSIS
COMPARING TREATMENT A (ULTRAVIOLET OZONOLYSIS- VJCA CORRECTED))
WITH TREATMENT B (ULTRAVIOLET OZONOLYSIS. LCWSL-VJCA FORMAT).
SYSTEM LIFESPAN TO BE 30 YEARS WITH 350 OP. DAYS PER YEAR.
ANALYSES ARE OVER FIVE YEAR SPANS (OR 'HORIZONS').

TOTAL CAPITAL COSTS FOR ALTERNATIVE A = $ 632000 AND FOR ALTERNATIVE B = $ 1100000;
RATIO OF CAPITAL COSTS OF B TO CAPITAL COSTS OF A = 1.74; DISCOUNT RATE = .02;
FLOW RATIO OF A TO B ('ALPHA') = 1.0000
DAILY FLOW IN SYSTEM A = 100 000 GALLONS: SYSTEM B = 100 000 GALLONS.

PVUC RECONCILIATION - VJCA (CORRECTED) WITH LCWSL IN VJCA METHOD.

VALUES USED FOR DECISION PROCESS	TOTAL YR 1 TO 5	TOTAL YR 1 TO 10	TOTAL YR 1 TO 15	TOTAL YR 1 TO 20	TOTAL YR 1 TO 25	TOTAL YR 1 TO 30
TOT. OP. COSTS FOR ALTERN. A $	1546000	2946000	4214000	5363000	6403000	7346000
TOT. OP. COSTS FOR ALTERN. B $	1084000	2065000	2955000	3760000	4490000	5151000
DISCOUNT SALVAGE VALUE FOR A $	477000	345000	234000	141000	64000	0
DISCOUNT SALVAGE VALUE FOR B $	830000	601000	408000	246000	111000	0
SLVG PER DISCNT CAP. (THETA-A)	.68362	.44864	.27603	.15096	.06192	< 10E-5
SLVG PER DISCNT CAP. (THETA-B)	1.18985	.78087	.48044	.26275	.10777	< 10E-5
TOT. FLOW (MGAL) FOR ALTERN A	175	350	525	700	875	1050
TOT. FLOW (MGAL) FOR ALTERN B	175	350	525	700	875	1050
RSUM FOR ALTERNATIVE A	7.43554	26.40127	55.81024	94.67799	????????	????????
RSUM FOR ALTERNATIVE B	5.21394	18.51308	39.13523	66.39005	99.65228	????????
THE DISCRIMINANT IS	1.9873	7.4799	16.1389	27.6592	41.7658	58.2110
PVUC ($/KGAL PROCESSED): A $	9.71	9.23	8.78	8.36	7.96	7.96
PVUC ($/KGAL PROCESSED): B $	7.73	7.32	6.94	6.59	6.26	6.26
UNIFORM ANNUAL COST (A) $	10.31	10.28	10.25	10.22	10.20	10.17
UNIFORM ANNUAL COST (B) $	8.20	8.15	8.10	8.06	8.01	7.97

STUDY CONDUCTED BY C.V. CICCONE NOVEMBER 29 1982

PRESENT VALUE/UNIFORM ANNUAL COST ANALYSIS USING DOD FORMAT
Cost Data By: LCWSL (ORIGINAL CORRECTED FOR S.V. CALCULATIONS)

1. Cost Data: Unadjusted
2. Discount Rate: 10%
3. Discount Comp: C.C.
4. Proj./Econ: Life 32 Yrs./30 Yrs.
5. Plant Cap. /GPD 100 k
" " M/GPY .035 k
6. Salvage Value Yr. 13th
7. Cap. Cost Spread 2 Yrs.
8. Cap. Cost Disc: 2
9. Lead Time O&M: 2 Yr(s)
10. Base Period Costs: Aver.'80

System Analyzed: ULTRAVIOLET OZONOLYSIS (UV OZONE)

Proj. Year (FY)	Econ. Year (FY)	PROGRAM/PROJECT COSTS (MILLIONS $) Non-Recurring Cost a. R&D	b. Investment	c. Recurring/ Operating Costs	d. Annual Cost (Sum a,b,c)	e. Discount Factor	f. Discounted Annual Cost (d times e)
1			.733			.954	.699
2			.367			.867	.318
3	1			.230		.788	.181
4	2			.230		.717	.165
5	3			.230		.652	.150
6	4			.230		.592	.136
7	5			.230		.538	.124
8	6			.230		.489	.112
9	7			.230		.445	.102
10	8			.230		.405	.093
11	9			.230		.368	.085
12	10			.230		.334	.077
13	11	S.V. =	.733 (based	on 30-yr.	proj. life)	.304	(-.223)
Totals							

9. Total Discounted Project Cost (Col. 8f. Total)..... $ 2.242
10. Discounted Salvage Value of Investments..... - .223
11. Net Total Discounted Project Costs (Line 9 less 10)..... $ 2.019
12. Line 11 / Tot.Flow/K = 2.019 / .350 = ... PVUC /k Gals $5.77
13. Line 11 / Tot. O&M Factors = 2.019 / 5.328 = U.A.C $ .379
14. Line 13 / 1 Yr's. Flow = .379 / .035 = ... UAC/K Gals $ 10.83

TABLE 16(b)

TABLE 17

PVUC ANALYSIS RECONCILIATION

PROCESS: ULTRAVIOLET OZONOLYSIS

LCWSL - VJCA

($ in Millions)

At Ten-Year Horizons

PROCEDURE: VJCA ORIGINAL (CORRECTED) - LCWSL (VJCA METHOD)

		VJCA	LCWSL	DIFFERENCE
1.	Cost Data:			
	Capital Costs	.623	1.100	-$.432 for VJCA
	O&M Costs	.328	.230	+$.098/yr. for VJCA(*)
2.	Discount Rate	2%	2%	Same
3.	Discount Comp	D.C.F.	D.C.F.	Same
4.	Project Life	31 yrs.	31 yrs.	Same
	Economic Life	30 yrs.	30 yrs.	Same
5.	Plant Cap/GPD	100,000	100,000	Same
6.	Salvage Value Year	10th	10th	Same
7.	Capital Cost Yr. Spread	1 yr.	1 yr.	Same
8.	Capital Cost Discount	None	None	Same
9.	Lead Time to O&M	1 yr.	1 yr.	Same
10.	Base Period (Costs)	Dec 1980	Avg. 1980	Higher for VJCA.
				Ratio
11.	PVUC/k gals.	$9.23	$7.32	1.26
12.	UAC/k gals.	$10.28	$8.15	1.26

(*) Note: The $.664 higher net total cost for VJCA (.098 x 10 + -$.432) accounts for most of the reason for the higher PVUC and UAC for VJCA.

TABLE 17(a)

PRESENT VALUE UNIT COST ANALYSIS
COMPARING TREATMENT A (ULTRAVIOLET OZONOLYSIS- VJCA CORRECTED))
WITH TREATMENT B (ULTRAVIOLET OZONOLYSIS, LCWSL-VJCA FORMAT)).
SYSTEM LIFESPAN TO BE 30 YEARS WITH 350 OP. DAYS PER YEAR.
ANALYSES ARE OVER FIVE YEAR SPANS (OR 'HORIZONS').

TOTAL CAPITAL COSTS FOR ALTERNATIVE A = $ 632000 AND FOR ALTERNATIVE B = $ 1100000;
RATIO OF CAPITAL COSTS OF B TO CAPITAL COSTS OF A = 1.74; DISCOUNT RATE = .02;
FLOW RATIO OF A TO B ('ALPHA') = 1.0000
DAILY FLOW IN SYSTEM A = 100 000 GALLONS: SYSTEM B = 100 000 GALLONS.

PVUC RECONCILIATION - VJCA (CORRECTED) WITH LCWSL IN VJCA METHOD.

VALUES USED FOR DECISION PROCESS	TOTAL YR 1 TO 5	TOTAL YR 1 TO 10	TOTAL YR 1 TO 15	TOTAL YR 1 TO 20	TOTAL YR 1 TO 25	TOTAL YR 1 TO 30
TOT. OP. COSTS FOR ALTERN. A $	1546000	2946000	4214000	5363000	6403000	7346000
TOT. OP. COSTS FOR ALTERN. B $	1084000	2065000	2955000	3760000	4490000	5151000
DISCOUNT SALVAGE VALUE FOR A $	477000	345000	234000	141000	64000	0
DISCOUNT SALVAGE VALUE FOR B $	830000	601000	408000	246000	111000	0
SLVG PER DISCNT CAP. (THETA-A)	.68362	.44864	.27603	.15096	.06192	< 10E-5
SLVG PER DISCNT CAP. (THETA-B)	1.18985	.78087	.48044	.26275	.10777	< 10E-5
TOT. FLOW (MGAL) FOR ALTERN A	175	350	525	700	875	1050
TOT. FLOW (MGAL) FOR ALTERN B	175	350	525	700	875	1050
RSUM FOR ALTERNATIVE A	7.43554	26.40127	55.81024	94.67799	????????	????????
RSUM FOR ALTERNATIVE B	5.21394	18.51308	39.13523	66.39005	99.65228	????????
THE DISCRIMINANT IS	1.9873	7.4799	16.1389	27.6592	41.7658	58.2110
PVUC ($/KGAL PROCESSED): A $	9.71	9.23	8.78	8.36	7.96	7.96
PVUC ($/KGAL PROCESSED): B $	7.73	7.32	6.94	6.59	6.26	6.26
UNIFORM ANNUAL COST (A) $	10.31	10.28	10.25	10.22	10.20	10.17
UNIFORM ANNUAL COST (B) $	8.20	8.15	8.10	8.06	8.01	7.97

STUDY CONDUCTED BY C.V. CICCONE

NOVEMBER 29 1982

APPENDIX D

SENSITIVITY ANALYSIS OF CAPITAL (INVESTMENT) COSTS AND ANNUAL RECURRING COSTS (O&M)

SENSITIVITY ANALYSIS OF CAPITAL (INVESTMENT) COSTS
AND ANNUAL RECURRING COSTS (O&M)

USING VJCA COST DATA Vs. LCWSL COST DATA FOR
ULTRAVIOLET OZONOLYSIS
(@10% Discounting)
($ in millions)

ORIGINAL COST DATA:

	VJCA	LCWSL	% DIFFERENCE
Capital Cost	$ .623	$1.100	+43.4%
O&M Costs	$ .328	$ .230	-29.8%

NET PRESENT VALUES @ DIFFERENT CHANGES IN COSTS: VJCA DATA

1. Capital Costs:

Percent Change	NPV
-100%	$3.22
- 50%	3.53
0	3.87
+ 50%	4.18

2. O&M Costs:

Percent Change	NPV
-100%	$0.62
- 50%	2.25
0	3.87
+ 50%	5.49

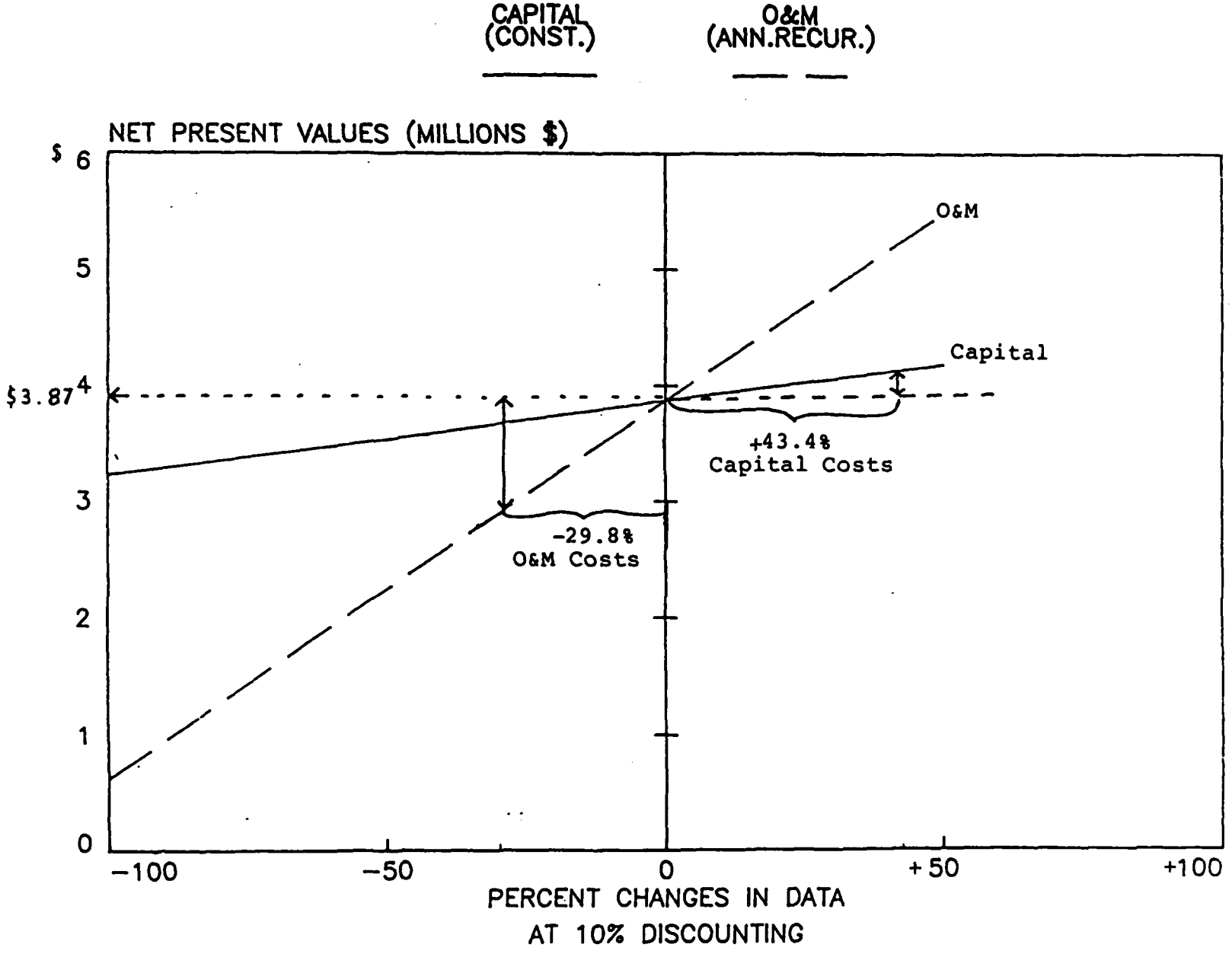
(See attached chart.)

Conclusion:

1. O&M costs (annual recurring costs) are much more sensitive to changes in costs than Construction (Capital) costs.

2. Even though there is a 43.4% difference between LCWSL's and VJCA's Construction costs (1.100 vs. .623) this difference will not have as great an impact on Net Present Values as the smaller (29.8%) difference in O&M costs.

KCOSTS–O&M COSTS SENSITIVITY ANALYSIS
ULTRAVIOLET OZONOLYSIS–VJCA DATA



APPENDIX E

INFLATION UNCERTAINTY ANALYSIS

INFLATION UNCERTAINTY ANALYSIS

Ultraviolet Ozonolysis Uncertainty Analysis: To test differences in PVUC's at various levels of discounting (inflation) between Alternative A (VJCA) and Alternative B (LCWSL) costing data.

UV Ozone - 30-Year Economic Life

($ in millions)

BASELINE (No Differential Escalation Rate) = 10 % Discount Rate

			NPV	RATIO
Alt. A:	VJCA:	$.623(1.000) + $.328(9.891)	= $3.87	1.15
Alt. B:	LCWSL:	$1.100(1.000) + $.230(9.891)	= $3.37	

2% EXTRA ESCALATION RATE = 8% Discount Rate

Alt. A:	VJCA:	$.623(1.000) + $.328(11.869)	= $4.52	1.18
Alt. B:	LCWSL:	$1.100(1.000) + $.230(11.869)	= $3.83	

4% EXTRA ESCALATION RATE = 6% Discount Rate

Alt. A:	VJCA:	$.623(1.000) + $.328(14.515)	= $5.38	1.21
Alt. B:	LCWSL:	$1.100(1.000) + $.230(14.515)	= $4.44	

6% EXTRA ESCALATION RATE = 4% Discount Rate

Alt. A:	VJCA:	$.623(1.000) + $.328(18.111)	= $6.56	1.24
Alt. B:	LCWSL:	$1.100(1.000) + $.230(18.111)	= $5.27	

8% EXTRA ESCALATION RATE = 2% Discount Rate

Alt. A:	VJCA:	$.623(1.000) + $.328(23.070)	= $8.19	1.28
Alt. B:	LCWSL:	$1.100(1.000) + $.230(23.070)	= $6.41	

Conclusions:

Testing for the uncertainty of future inflation rates and the effect such rates will have on discount factors, shows the impact of the different rates on the Net Present Values over the 30-year life cycle of the project's economic returns, and that the different discount rates do not change the least-cost ordering between the two alternatives (A=VJCA, B=LCWSL).

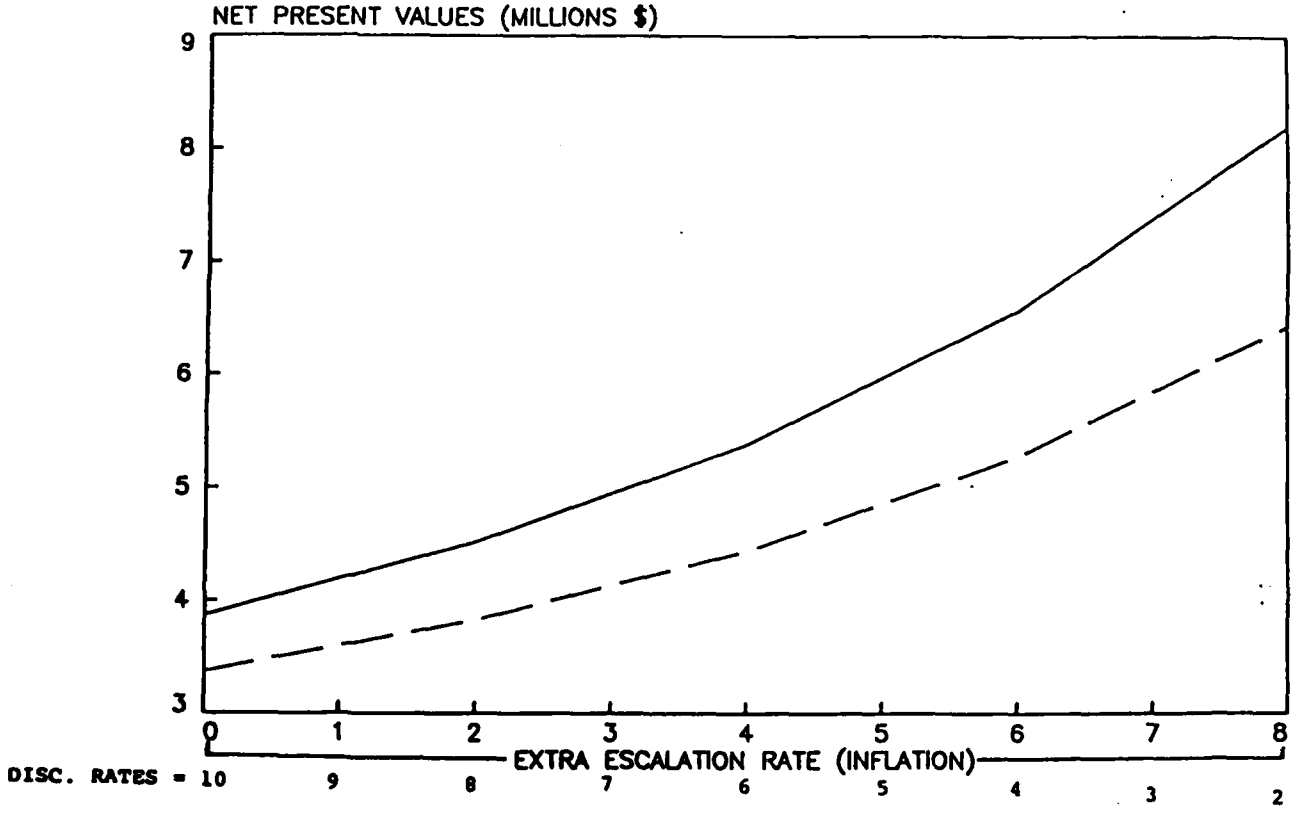
When higher inflation rates are forecasted, it reduces the discount rate (the real rate of return (rate of return netted out for inflation)) thereby increasing the Net Present Value as well as widening the difference between each alternative's Net Present Value.

(See attached chart.)

INFLATION SENSITIVITY--UV OZONE

(OVER 30-YEAR ECONOMIC LIFE)

VJCA ———— LCWSL — —



Note:

Discount rates shown at the bottom of the above chart are derived by subtracting the Extra Excalation Inflation Rate (top number) from the 10% discount rate used by DoD in its base discounting table of factors. (Ex.: 10% - 0 Extra Escalation Rate = 10% Discount Rate, or 10% - 1% Extra Escalation Rate = 9% Discount Rate.) For additional information on Extra Excalation Inflation Rates, see NAVFAC P-442 Economic Analysis Handbook, 1980.

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